Comparison of Undisturbed and Remolded Samples using Triaxial Equipment

by

Siti Aisyah Bt Yahya

Dissertation submitted in partial fulfillment of
the requirements for the
Bachelor of Engineering (Hons)
(Civil Engineering)

JANUARY 2012

Universiti Teknologi PETRONAS
Bandar Seri Iskandar
31750 Tronoh
Perak Darul Ridzuan.

CERTIFICATION OF APPROVAL

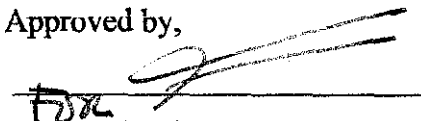
Comparison of Undisturbed and Remolded Samples using Triaxial Equipment

by

Siti Aisyah Bt Yahya

A project dissertation submitted to the
Civil Engineering Department
Universiti Teknologi PETRONAS
in partial fulfillment of the requirement for the
BACHELOR OF ENGINEERING (Hons)
(CIVIL ENGINEERING)

Approved by,



(Dr. Syed Baharom Azahar Syed Othman)

UNIVERSITI TEKNOLOGI PETRONAS
TRONOH, PERAK
January 2012

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

(SITI AISYAH BT YAHYA)

ABSTRACT

Geotechnical engineers or engineering geologist performed geotechnical investigation to obtain information on the physical properties of soil and rock around a site to design earthworks and foundations for proposed structures.

A wide variety of laboratory tests can be performed on soils to measure a wide variety of soil properties. Some soil properties are intrinsic to the composition of the soil matrix and are not affected by sample disturbance, while other properties depend on the structure of the soil as well as its composition, and can only be effectively tested on relatively undisturbed samples. Triaxial shear tests is a type of test that is used to determine the shear strength properties of a soil. It can simulate the confining pressure a soil would see deep into the ground. It can also simulate drained and undrained conditions.

This aim of this research is to compare the soil strength characteristics between undisturbed and remolded samples by testing both samples using Triaxial Equipment.

Several undisturbed sample will be collected using specified soil samplers together with a sufficient amount of soil to be prepared into remolded samples in the laboratory. The undisturbed and remolded sample will then be tested using Unconsolidated Undrained Triaxial Test.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1

INTRODUCTION

1.0 INTRODUCTION

1.1 Background of Study

Soil samples can be obtained using a variety of samplers that will determine the soil sample to be classified as disturbed samples or undisturbed samples.

Undisturbed sample is referring to the condition of the soil sample that is close enough to the conditions of the soil in-situ to allow tests of structural properties of the soil to be used to approximate the properties of the soil in-situ.

A remolded sample is referring to the conditions of which the soil sample has been compacted according to the desired density and moisture content. Remolded sample fall into the category of disturbed sample of which the structure of the soil has been changed sufficiently that tests of structural properties of the soil will not be representative of in-situ conditions.

Triaxial test is used to determine the stress-strain characteristics of soil under drained or undrained conditions. In a triaxial test, the cylindrical soil specimen is encased with a rubber sleeve inside a pressure chamber. The lower and upper loading plate have porous disc connected to the drainage system. The confining or cell pressure σ_3 is applied by adjusting the chamber pressure and the axial load (deviator load) is applied in a stress or strain controlled manner (constant).

There are three main types of Triaxial Test, which are named CD, UU and CU. The first letter C or U refers to the consolidation stage and stands for *consolidated* and *unconsolidated.* The second letter D or U refers to the drainage condition during shear and stand for drained and undrained.

Since the desired outcome is to determine the shear strength of soil by obtaining the total shear strength parameters (cohesion, *c* and angle of internal friction, ϕ), the author is going to conduct **Unconsolidated Undrained Triaxial Test**. In unconsolidated undrained triaxial test, the undrained condition is maintained when the cell pressure applied, and also during shearing. (The increase of deviator load to failure of specimen)

1.2 Problem Statement

There are many factors which determine the strength of soil. For undisturbed soil, its soil fabric gives significant influence towards the strength of the soil. Cohesive soil loses its strength due to sample disturbance since structure of the soil has been changed. On the other hand the remolded soil strength depends on the moisture content and degree of compaction and also other possible factors. Throughout this research, author investigated on how the sample disturbance would affect the undrained strength of soil sample

1.3 Objective and Scope of Study

The aim of this study is to compare the soil strength characteristics between undisturbed and remolded samples by testing both samples using Triaxial Equipment. In order for that, few objectives need to be achieved:

- To obtain the shear strength of undisturbed and remolded soil samples using Unconsolidated Undrained Triaxial Equipment.
- To discover the relationships of undrained strength between undisturbed and remolded samples

CHAPTER 2

LITERATURE REVIEW

2.0 LITERATURE REVIEW

2.2 Sample remolding

Soil as construction or foundation material can be used in its natural undisturbed state or remolded state to meet the specific requirement such as to obtain satisfactory engineering properties like shear strength, compressibility or permeability. When soil is remolded, the fabric of soil is progressively distrupted and the behavior of soil is altered.[M.Lukas]

As indicated in BS 3771, in the laboratory the soil remolding can be done by compacting the soil into a mold at specified moisture content by applying specified compaction method to achieved specified dry density.

2.3 Triaxial Test

The triaxial test is carried out in a cell and is so named because three principal stresses are applied to the soil sample. Two of the principal stresses are applied to the sample by a water pressure inside the confining cell and are equal (σ_3). The third principal stress is applied through a deviator load through the top of the cell at a constant rate. A diagram of a typical triaxial cell is shown below.

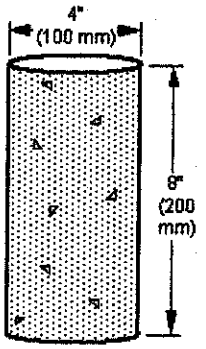


Figure 1a: Basic Triaxial Specimen Configuration

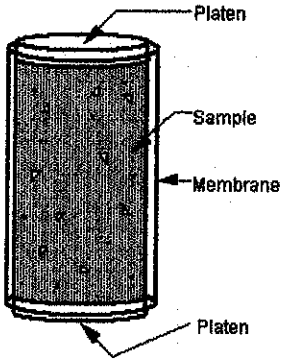


Figure 1b: Enclosure of Triaxial Specimen

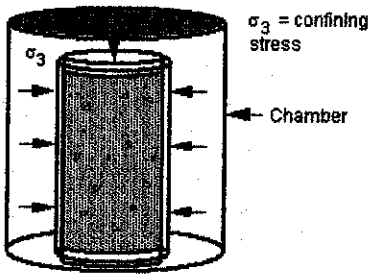


Figure 1c: Triaxial Specimen in Pressure Chamber

Figure 2.1: Diagram of A Typical Triaxial Cell

There are three main types of Triaxial Test, which are named CD, UU and CU. The first letter C or U refers to the consolidation stage and stands for *consolidated* and *unconsolidated.* The second letter D or U refers to the drainage condition during shear and stand for drained and undrained.

Consolidated Drained (CD) Test

There will be no excess pore pressure throughout the test, and subject to very slow shearing to avoid build-up of pore pressure. This test is commonly undesirable since it may take days to complete. This test will result with value of c' and ϕ'.

Consolidated Undrained (CU) Test

During this test, the pore pressure will develop during shear since the drainage is not allowed during the shearing. This test will result with value of c' and ϕ'. This test is the more preferred way rather that CD.

Unconsolidated Undrained (UU) Test

In unconsolidated undrained triaxial test, the undrained condition is maintained when the cell pressure applied, and also during shearing. (the increase of deviator load to failure of specimen). This test will result in cohesion, *c* and angle of internal friction, ϕ

The author conducted **Unconsolidated Undrained Triaxial Test** since the desired outcome is to determine the shear strength of soil by obtaining the total shear strength parameters

2.4 Soil Shear Characteristics

Shear strength is defined as the maximum strength of soil in at point in which plastic deformation and yielding occurs to an applied shear stress. Meanwhile, shear strength of a mass refers to the internal resistance per unit area that a soil can offer to resist failure and sliding along any plane (Das 2005)

Coulomb (1776) had conducted numerous tests and concluded that the shear strength of soil is comprised with two components, which are the cohesion (c) and the normal stress internal friction angle (ϕ)

The limiting shear stress that may be applied to any plane in the soil mass is found to be given by an equation of the form

$$t = c + \sigma_n \tan \phi$$

where c = cohesion (apparent)

ϕ = angle of internal friction

This is known as the Mohr-Coulomb failure criterion.

The relationship of the limiting shear stress is plotted as a straight line to obtain the shear strength parameters cohesion (c) and internal friction angle (ϕ)

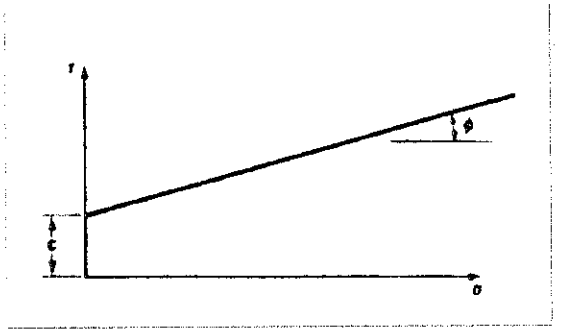


Figure 2.2: The graphically presented Coulomb Strength Equation

2.5 Review of Journals

Regarding this topic, there are few journals that the author managed to study and analyze.

Norshakila Muhamad Rawai in her thesis entitled Laboratory Study of Undrained Shear Strength of Pontian Clay: Comparison between Undisturbed and Remolded Sample has come up with results showing that the shear strength of remolded sample is way greater than undisturbed sample. However she explained that it occurs due to the fact that both samples are not tested under the same moisture content. The value of moisture content of her remolded sample was half less from the undisturbed sample.

Due to that, direct of shear strength comparison could not be made. Both samples should be tested under the same moisture content.

Zhenshun Hong, Songyu Liu, Shuilong Shen and Takohito Nagami in their journal entitled Comparison in Undrained Shear Strength between Undisturbed and Remolded Ariake Clay; have come up with results showing that for all samples, the undrained shear strength of remolded Ariake Clay is much larger than undisturbed Ariake Clay at the same confining stress. For further investigating the difference in strength behavior of undisturbed and remolded Ariake Clay, they have replotted the Triaxial Test result in the plots of undrained shear strength versus water content. The plot shows that the undrained shear strength decreases uniquely with the increase in water content. Hence the difference in strength behavior between undisturbed and remolded states is caused by the difference in water content.

Jiang, Hu, Peng, and Leroueil have come up with their research article entitled Experimental Study of Two Saturated Natural Soils and Their Saturated Remoilded Soils under Three Consolidated Undrained Stress Path. They had concluded that the strength on natural saturated loess is higher than the strength of remolded loess at low confining pressure while the strength on natural saturated loess is lower than the strength of remolded loess at high confining pressure. This is due to the fact that at low confining pressure, the contribution of bonds is significant meanwhile at high confining pressure, void gives major impact towards strength of soil.

Merihun Lukas, in his thesis entitled A Study on Effect of Remolding on The Mechanical Behavior of Addis Ababa Red Clay Soil has come up with graphs showing that Shear Stress of Undisturbed Samples are higher than remolded samples.

Kamei, Tanaka and Hayashi have come up with a journal entitled Comparison of Shear Characteristics of Undisturbed and Remolded Bangkok Clay. The main purpose of their study is to compare the stress-strain-strength behavior of the undisturbed and the remolded specimens of Bangkok clay. Quantitative test results show that the shear strength of the undisturbed samples is greater than those of the remolded samples. This difference is attributed to the fact that the soil structure of the undisturbed samples

offers greater resistance to external loading compared to the remolded samples in which the soil structure has been destroyed.

CHAPTER 3

METHODOLOGY/PROJECT WORK

3.0 METHODOLOGY

3.1 Project work

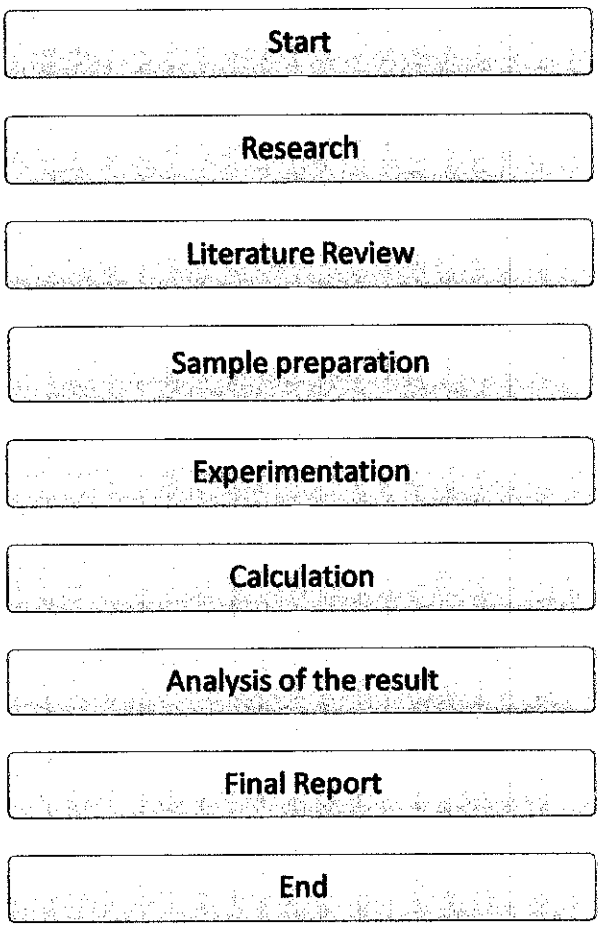


Figure 3.1: Project Activities Flow

3.2 Experimentation Operational Framework

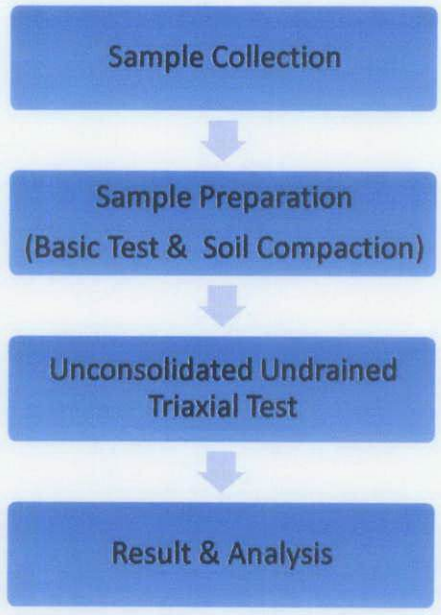


Figure 3.2: Experimental Framework

3.2.1 Sample collection

The soil samples are taken from 5 sites located around UTP. The sites are located at:

Site 1	Between Block 13 and 14
Site 2	Near Concrete Lab
Site 3	UTP Lake near old village cafe
Site 4	Near UTP back gate
Site 5	Near UTP back gate

Table 3.1: Site locations which soil samples are taken

From each site, the author took three specimens of undisturbed soil and a sufficient amount of disturbed soil (around 5 kg) to be produced as remolded sample.

Figure 3.3: disturbed samples taken from site 3, 4 and 5

The undisturbed samples are obtained using hand auger. The author hand-auger\until around two feet depth to obtain undisturbed sample. The two feet depth is decided because the upper layer of soil normally comprised of fill soil.

Figure3.4: Hand auger

Figure 3.5: Undisturbed sample in steel tube taken using hand auger

3.2.2 Sample preparation

After separating the disturbed soil sample from unnecessary objects such as big-sized gravel and grass' root, the sample is removed into a large square steel tray and being put into a oven for 24 hours at 100°c

Figure 3.6: disturbed sample in oven

After 24 hours, the sample is removed from the oven and crushed into very fine pieces using a rubber hammer.

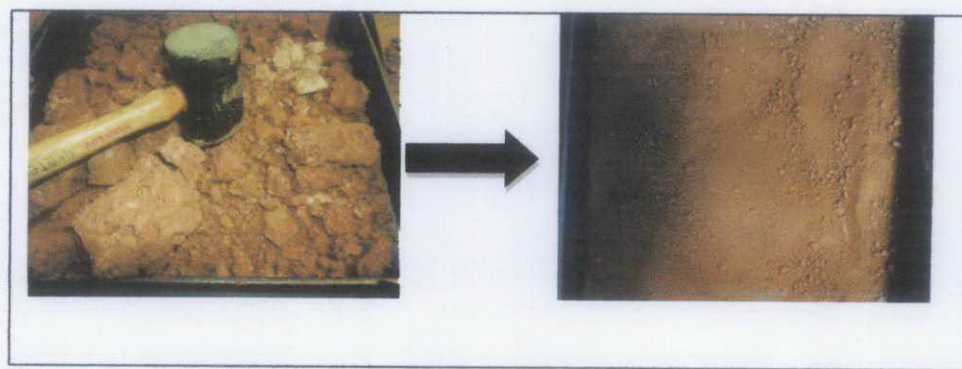


Figure 3.7: disturbed sample is crushed into fine pieces using rubber hammer

Some portion of the soil sample taken from each site will be separated and will have to undergo few basic tests as listed below before being tested with Triaxial equipment.

Basic Test

Moisture content determination (Oven drying method)

(This test is being done as soon as the sample is obtained from the site)

Brief Description: 3 specimens of weight around 30 grams of the soil each, is being put in a container which the container weight **(m_1)** have been recorded previously. The mass of the wet soil+ container **(m_2)** is recorded. The sample is then being put in an oven at 100°C for 24 hours. After 24 hours, the mass of the dried soil + container **(m_3)** is recorded.

Figure 3.8: specimen is being weighed and put in oven

Particle Size Distribution (PSD)

Brief Description: Sieves with respected size is cleaned and weighed. The sieves are stacked on the mechanical shaker with the largest sieve size on top and smallest sieve size at the bottom. Weighed oven dried sample is placed on top and covered with a lid. Agitate the test sieves on the mechanical shaker for 15 minutes. Each sieve is weighed with the soil retained.

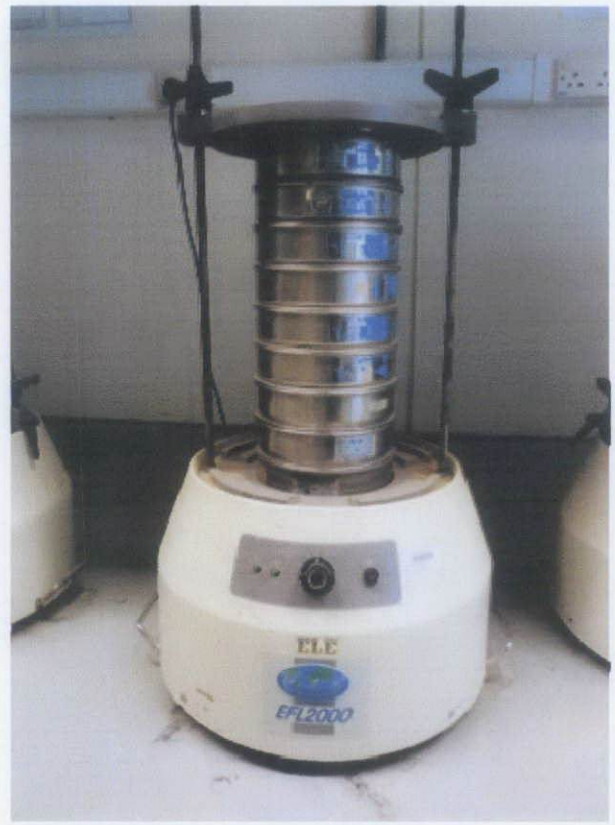


Figure 3.9: Sieve equipment

Plasticity Index (PI) determination

PI = Plastic Limit (PL) - Liquid Limit (LL)

Plastic Limit

Brief Description:

- Around 20 g of oven-dried soil from a sample of the soil passing through 425µm Sieve is taken.
- The soil is mixed with distilled water in an evaporating dish
- The soil is molded between palms and rolled

until a slight crack appear

- The sample is divided into 2 equal parts and each sub sample is divided into 4 more or less equal parts
- Take one divided sample and rolled with fingers on a glass plate. We should form a 3mm diameter thread
- Repeat the process of alternate rolling and kneading until the thread crumbles.
- Collect and keep the pieces of crumbled soil thread in the container used to determine the moisture content.
- Repeat the sample procedure for remaining sample and proceed to take the moisture content for each specimen.

Liquid Limit

Brief Description:

- A soil sample weighed at least 300 g passing 425µm test sieve is placed onto a glass plate
- The sample is mixed with some distilled water and mixed using 2 spatulas for at least 10 minutes
- The sample is pushed into a metal cup using a straightedge
- The metal cup is placed on the equipment and adjusted so that the tip of the cone just touch the soil surface
- The cone is released for 5 seconds so that it may penetrate the soil
- Reading is taken to measure depth of penetration

3.2.2.1 Preparation of Remolded Sample

To prepare remolded sample: Around 3 kg of oven-dried soil is taken. The amount of water to be mixed into the soil is based on the obtained moisture content for each sample. The soil is then mixed thoroughly with specified amount of water using mixer.

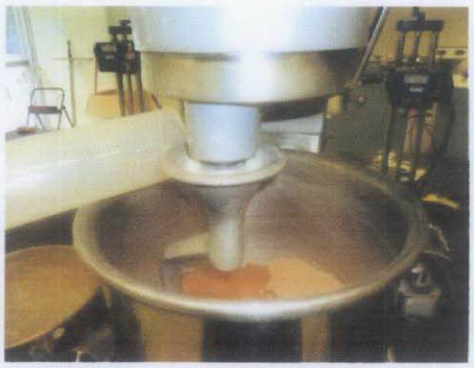


Figure3.10: The soil is being mixed with water using mixer

The water-mixed sample is the kept in a sealed tray while waiting to be compacted to avoid any moisture loss.

Figure 3.11: Sealed sample

The soil is then compacted through 3 layers with 27 blows for each layer

Figure 3.12: Soil compaction

After the 3 layers of compaction have been done, the mould collar is removed and excessive soil is trimmed using a scrapper

Figure 3.13: compacted soil

Three triaxial test mould is placed onto the compacted soil using hammer and pushed inside using extruder. The sample is then extruded to obtain remolded sample

Figure 3.14: triaxial test mould is placed onto the compacted soil

The extruded sample is then wrapped carefully and stored in a desiccator to avoid moisture loss

Figure 3.15: samples are wrapped and stored in a dessicator

3.2.3 Unconsolidated Undrained Triaxial Test

From each site the author prepare three undisturbed specimen and three remolded specimen. Each specimen will be subjected to a confining pressure.

Since the soil samples are taken from five sites, the total number of specimens that would be tested under Unconsolidated Undrained Triaxial Test would be 30 specimens.

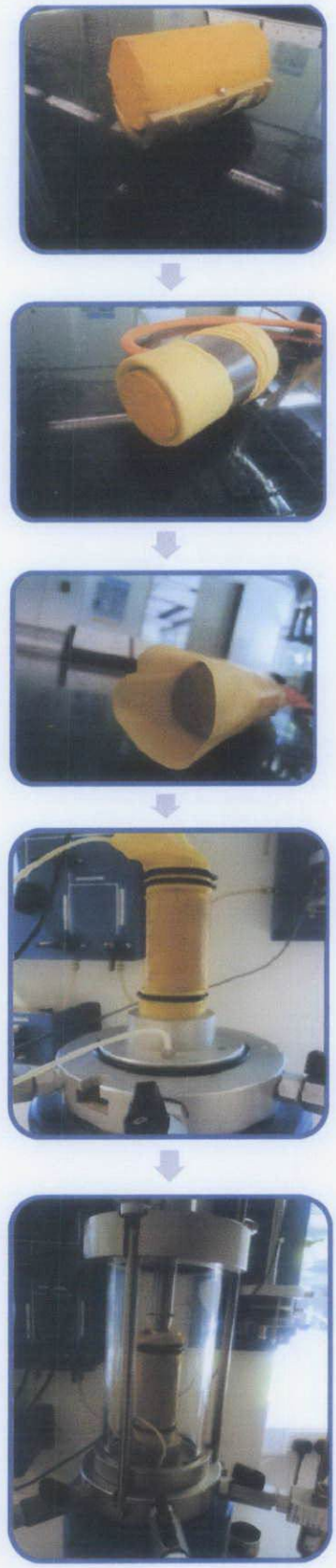
Sample	Plasticity Index	Condition	Confining Stress	Nos of Specimen
Soil 1	PI_1	Undisturbed	$\sigma_{3,1}$ = 100kPa	1
			$\sigma_{3,2}$ = 200kPa	2
			$\sigma_{3,3}$ = 400kPa	3
		Remolded	$\sigma_{3,1}$ = 100kPa	4
			$\sigma_{3,2}$ = 200kPa	5
			$\sigma_{3,3}$ = 400kPa	6
Soil 2	PI_2	Undisturbed	$\sigma_{3,1}$ = 100kPa	7
			$\sigma_{3,2}$ = 200kPa	8
			$\sigma_{3,3}$ = 400kPa	9
		Remolded	$\sigma_{3,1}$ = 100kPa	10
			$\sigma_{3,2}$ = 200kPa	11
			$\sigma_{3,3}$ = 400kPa	12
Soil 3	PI_3	Undisturbed	$\sigma_{3,1}$ = 100kPa	13
			$\sigma_{3,2}$ = 200kPa	14
			$\sigma_{3,3}$ = 400kPa	15
		Remolded	$\sigma_{3,1}$ = 100kPa	16

			$\sigma_{3,2}$ = 200kPa	17
			$\sigma_{3,3}$ = 400kPa	18
Soil 4	PI_4	Undisturbed	$\sigma_{3,1}$ = 100kPa	19
			$\sigma_{3,2}$ = 200kPa	20
			$\sigma_{3,3}$ = 400kPa	21
		Remolded	$\sigma_{3,1}$ = 100kPa	22
			$\sigma_{3,2}$ = 200kPa	23
			$\sigma_{3,3}$ = 400kPa	24
Soil 5	PI_5	Undisturbed	$\sigma_{3,1}$ = 100kPa	25
			$\sigma_{3,2}$ = 200kPa	26
			$\sigma_{3,3}$ = 400kPa	27
		Remolded	$\sigma_{3,1}$ = 100kPa	28
			$\sigma_{3,2}$ = 200kPa	29
			$\sigma_{3,3}$ = 400kPa	30

\

\Table 3.2 : Confining pressure applied to each specimens.

Final stages of sample preparation for UU Triaxial Test



Triaxial Test Procedure

- Axial load piston is brought to contact with the specimen cap. (Must be done in special care so that the specimen would not be overloaded with the weight of the piston during testing)
- Chamber pressure maintaining and measuring device is attached and adjusted to provide the desired chamber pressure
- Chamber is filled with confining liquid (water) and placed in position in the axial loading device
- Axial load measuring device is adjusted to read zero
- Confining pressure is applied
- Sufficient reading is taken to capture the stress-strain curve

3.2.4 Result and Analysis

Basic Tests

Summary of basic tests result. (Refer attachment for detailed test result and calculation)

Sample	1	2	3	4	5
Moisture Content	22	15	9	28	24
Liquid Limit	38	33	24	47	28.5
Plastic limit	24	16	19	34	22
Plasticity Index	14	17	5	13	6.5
Particle Size Distribution	Refer attachment				

Table 3.3: Summary of basic test results

Triaxial Test

Figure 3.17: example of sheared sample (sample 3)

The graph of Deviator Stress versus Axial Strain plotted for each applied confining stress value (σ_3).

Shearing Stage of Sample 4 (Undisturbed)

Sample 4UD A (Cell Pressure = 100 kPA)

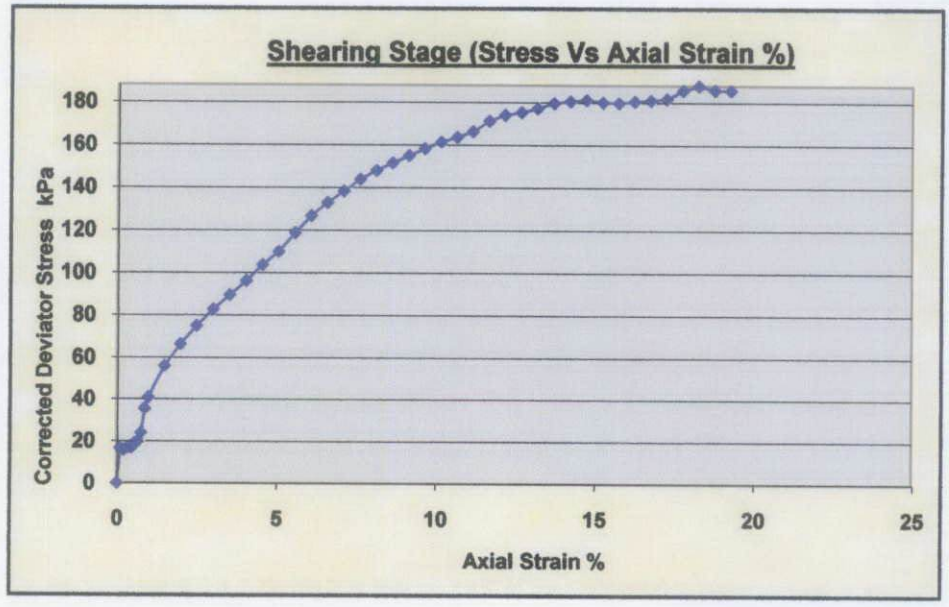


Figure 3.18: Shearing stage of Sample 4 UD (A)

Sample 4UD B (Cell Pressure = 200 kPA)

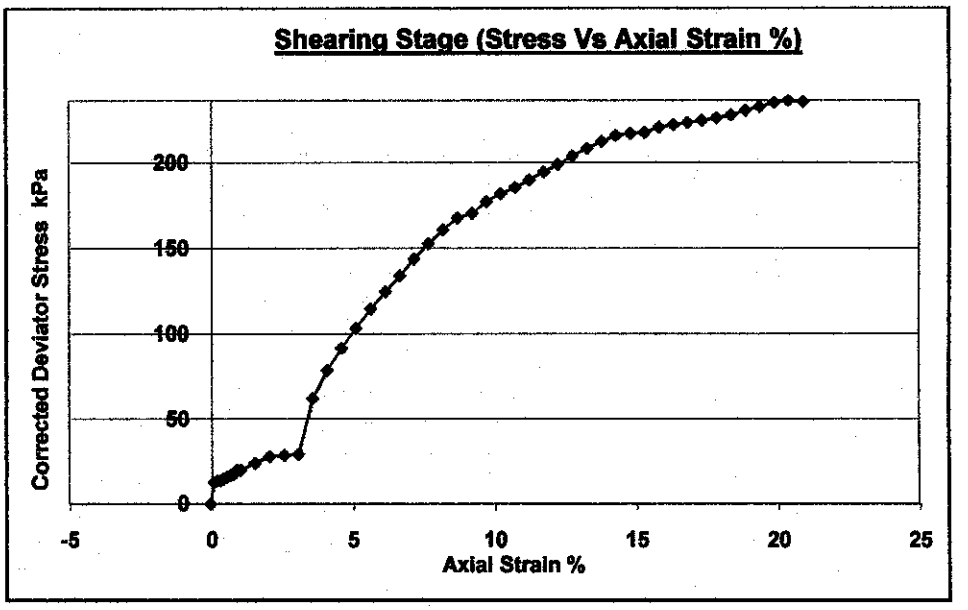


Figure 3.19: Shearing stage of Sample 4 UD (B)

Sample 4UD C (Cell Pressure = 400 kPA

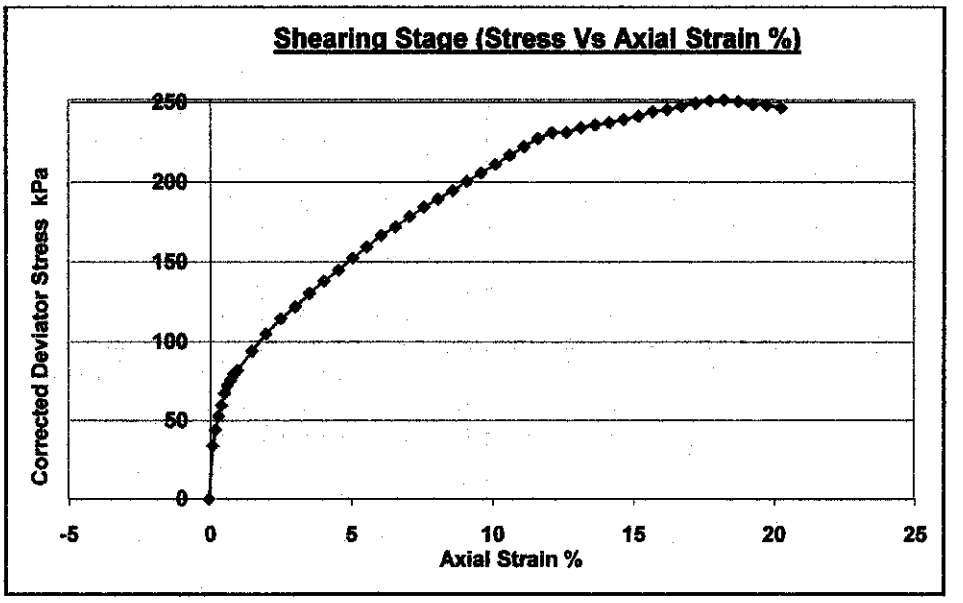


Figure 3.19: Shearing stage of Sample 4 UD (C)

From the graph, the value of maximum deviator stress (σ_p) is obtained and would lead to get the value of total axial stress (σ_1) which will be used to plot Mohr Circle.

Conditions at failure of Sample 4 UD

All Stages Conditions at Failure for Sample 4 (Undisturbed)				
Ref	**Cell Pressure**	**Max. Corrected Deviator Stress**	**Cumulative Strain**	**Mode of Failure**
Stage1	99.0kPa	188kPa	18.26%	Maximum Deviator Stress or Maximum allowed Strain
Stage2	198.9kPa	236kPa	20.42%	Maximum Deviator Stress or Maximum allowed Strain
Stage3	398.0kPa	251kPa	18.27%	Maximum Deviator Stress or Maximum allowed Strain

Table 3.4 : Conditions at failure of Sample 4 UD

Mohr circle will be plotted based on the obtained result.

Mohr Circle of Sample 4 (Undisturbed)

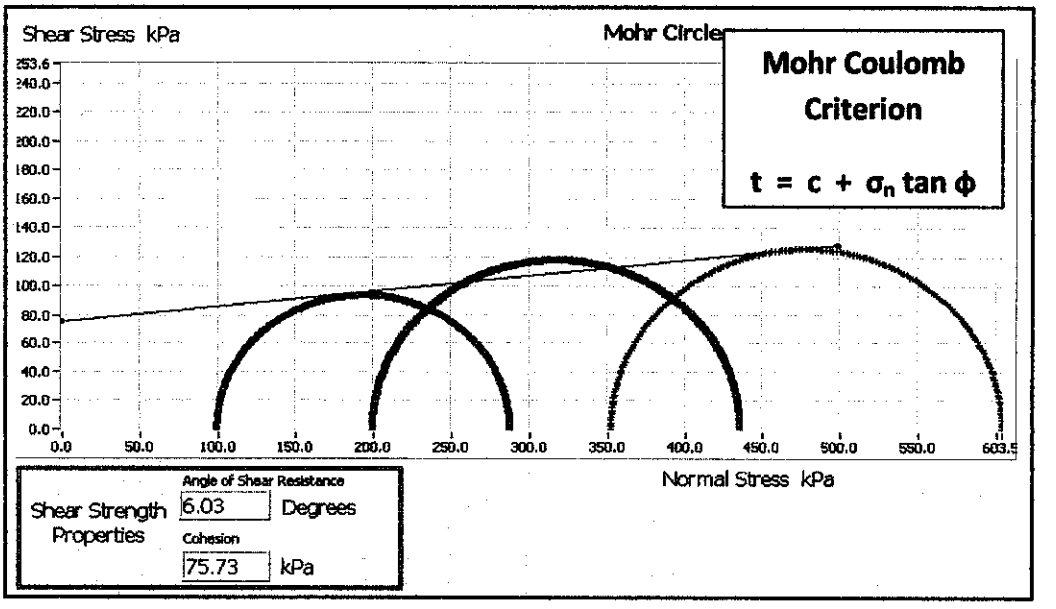


Figure 3.20: Mohr Circle of Sample 4 UD

From the Mohr Circle, the value of shear strength properties; cohesion, c and angle of internal friction, ϕ is obtained

Sample 4 (Undisturbed)		
Cohesion, c		75.73 kPa
Angle of internal friction, ϕ		6.03°
Shear strength	A	94 kPa
	B	118 kPa
	C	126 kPa

Table 3.5: Shear strength properties of Sample 4 UD

The value of shear strength is calculated based on the Mohr Coulomb equation

$$t = c + \sigma \tan \phi$$

Shearing stage of Sample 4 (Remolded)

Sample 4R A (Cell Pressure = 100 kPa)

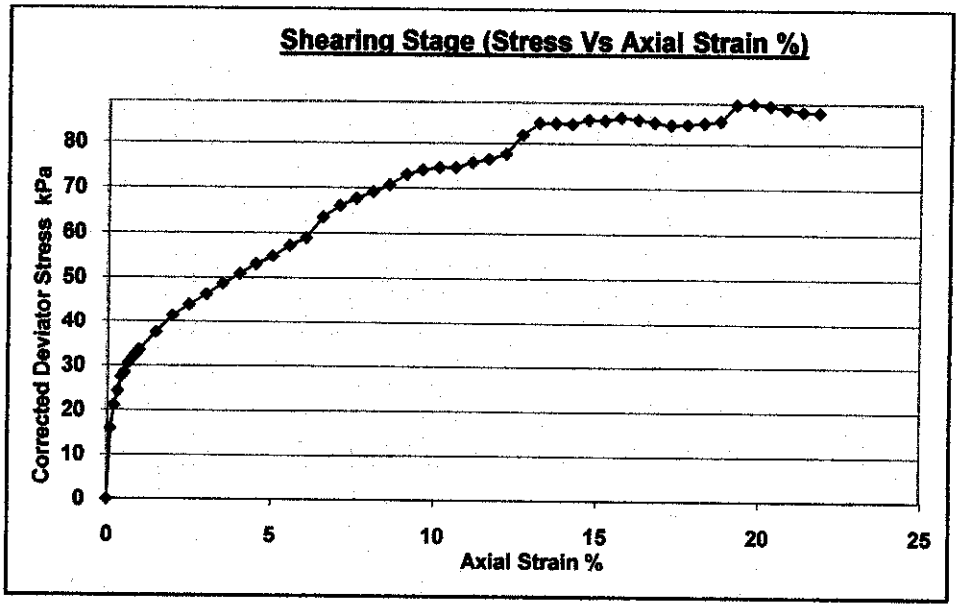


Figure 3.21: Shearing stage of Sample 4 R (A)

Sample 4R B (Cell Pressure = 200 kPa)

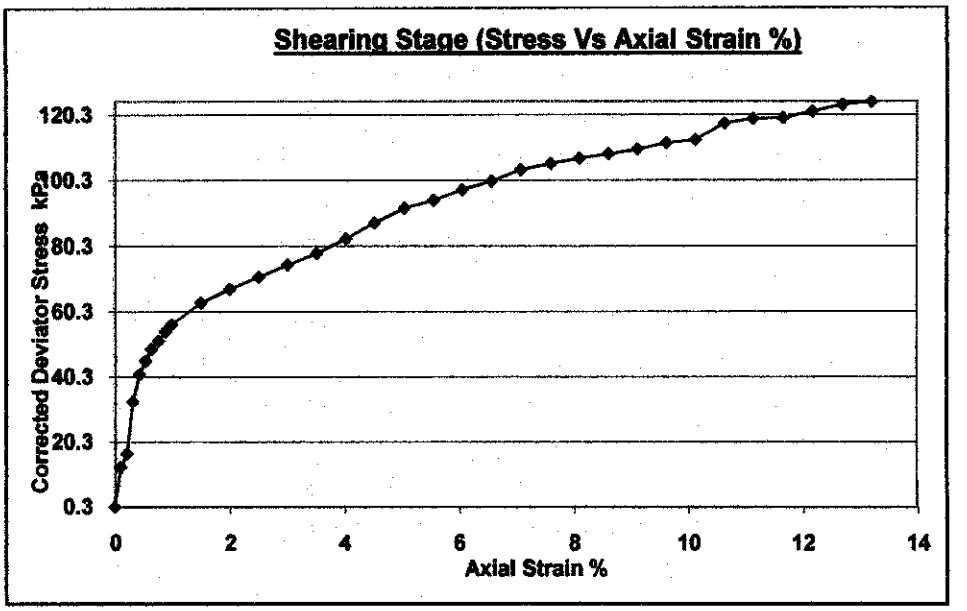


Figure 3.21: Shearing stage of Sample 4 R (A)

Sample 4R C (Cell Pressure = 400 kPa)

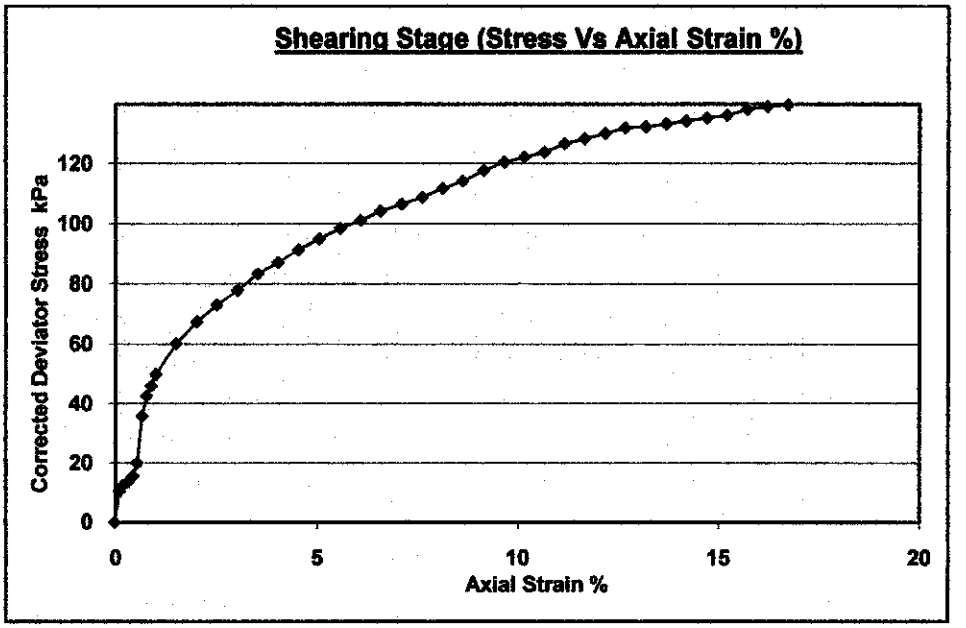


Figure 3.22: Shearing stage of Sample 4 R (C)

Conditions at Failure for Sample 4 (Remolded)

All Stages Conditions at Failure for Sample 4 (Remolded)				
Ref	**Cell Pressure**	**Max. Corrected Deviator Stress**	**Cumulative Strain**	**Mode of Failure**
Stage1	99.6kPa	89kPa	19.31%	Maximum Deviator Stress or Maximum allowed Strain
Stage2	199.6kPa	124kPa	13.21%	Maximum Deviator Stress or Maximum allowed Strain
Stage3	312.9kPa	140kPa	16.77%	Maximum Deviator Stress or Maximum allowed Strain

Table 3.6: Conditions at Failure for Sample 4 (Remolded)

Mohr Circle of Sample 4 (Remolded)

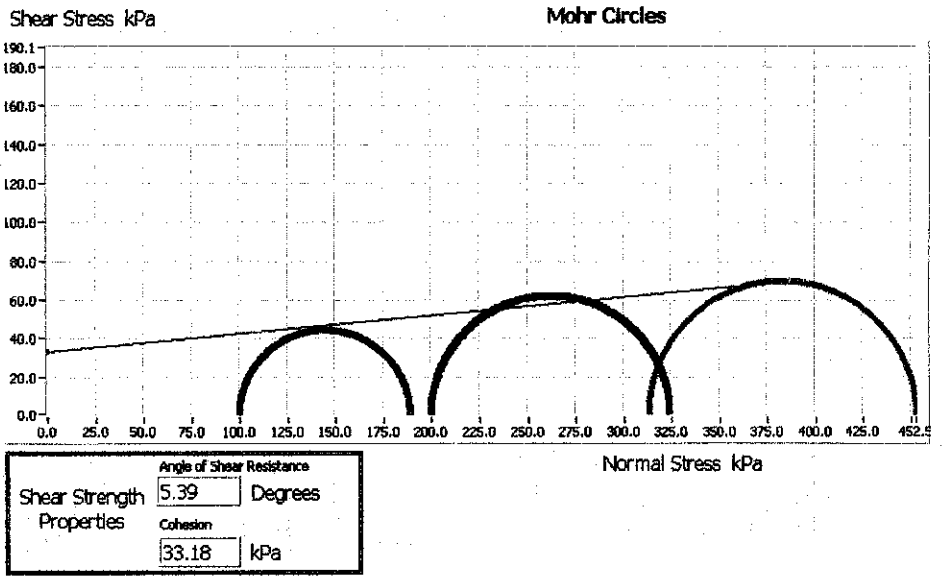


Figure 3.23: Mohr Circle of Sample 4 (Remolded)

Sample 4 (Remolded)		
Cohesion, c		33.18 kPa
Angle of internal friction, ϕ		5.39°
Shear strength	A	44 kPa
	B	62 kPa
	C	70 kPa

Table 3.7: Shear strength properties of Sample 4

Shear strength of all soil samples

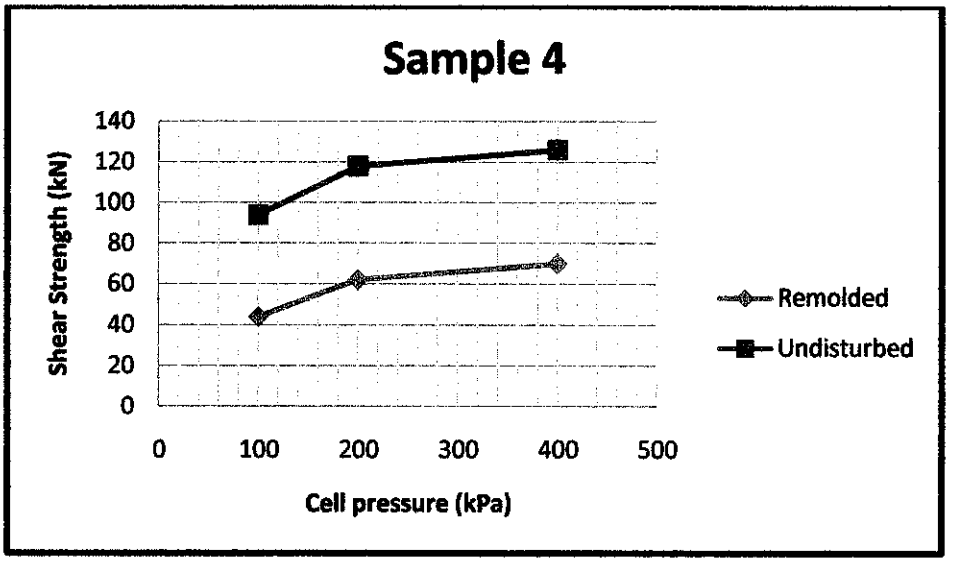


Figure 3.24: Shear strength of Sample 4 (Undisturbed and Remolded)

For sample 4, it shows that the shear strength of undisturbed samples is higher than remolded samples. The same goes to sample 1, 2 and 5.

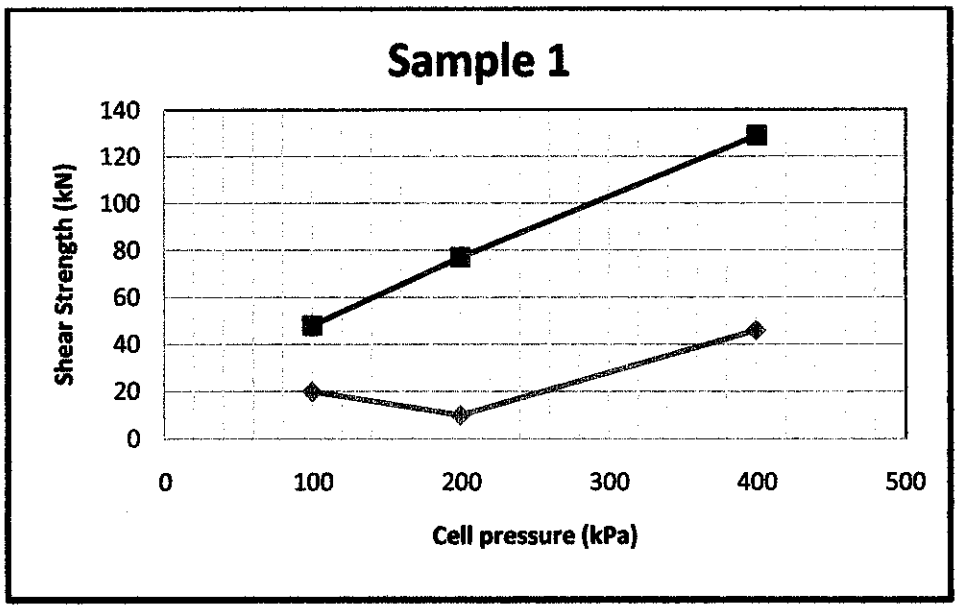


Figure 3.25: Shear strength of Sample 1(Undisturbed and Remolded)

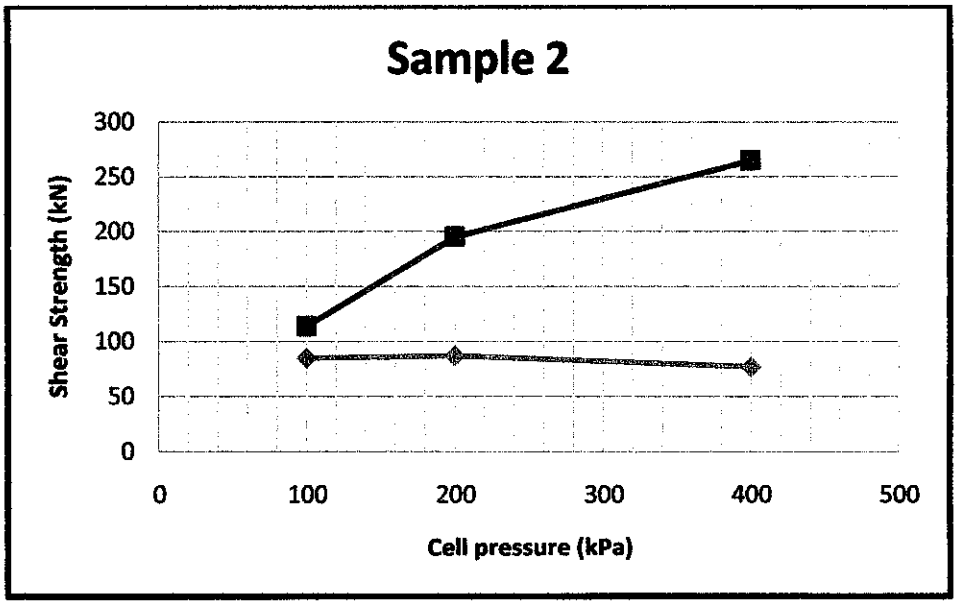


Figure 3.26: Shear strength of Sample 2 (Undisturbed and Remolded)

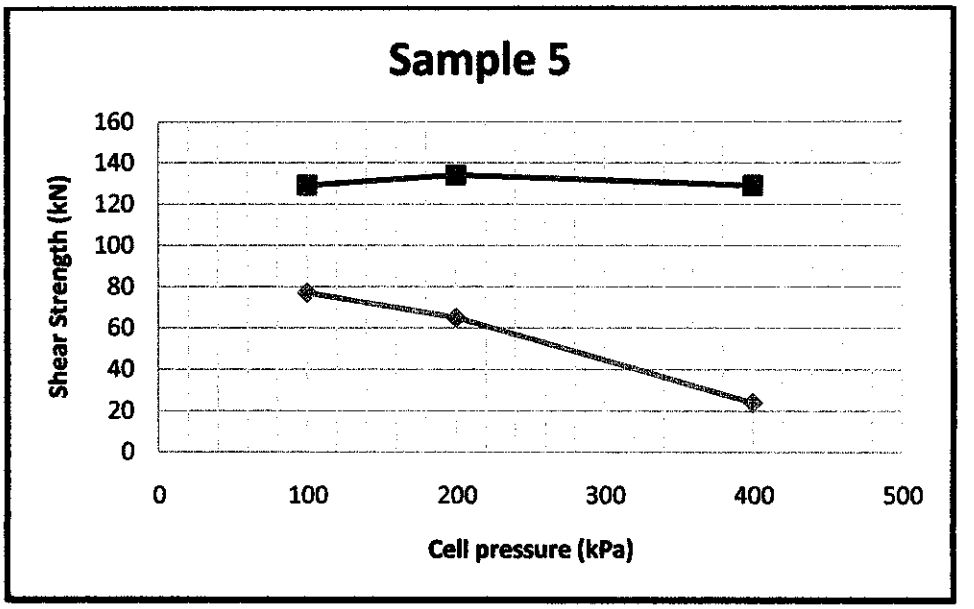


Figure 3.27: Shear strength of Sample 5 (Undisturbed and Remolded)

However, different case applied to sample 3. The remolded samples have higher shear strength values.

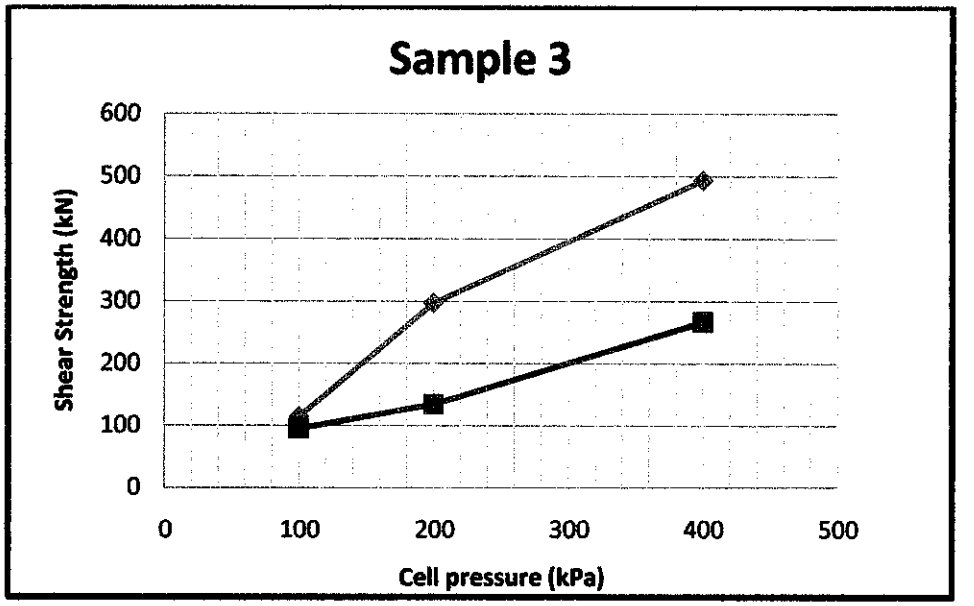


Figure 12: Shear strength of Sample 3 (Undisturbed and Remolded)

Shear strength properties of all soil sample

Sample	Shear Strength Properties			
	Undisturbed		Remolded	
	Φ (°)	Cohesion,c (kPa)	Φ (°)	Cohesion,c (kPa)
Soil 1	12.7	19.5	4.52	11.07
Soil 2	11.58	51.14	0	83.58
Soil 3	20.45	28.96	32.91	3.92
Soil 4	6.93	75.73	6.39	29.35
Soil 5	0.20	129.9	-11.9	117.3

Table 3.8: Shear strength properties for undisturbed and remolded sample

Sample 3 have higher shear strength values because it consists of less cohesive soil, which is proven by its Particle Size Distribution.

For sample 3, D30 = 300 mm, which means 30% of sample is finer than 300 mm. Compared to other samples such as sample 4, D30 = 212 mm; which means 30% of samples is finer than 212 mm. The same goes to other percentages.

This proved that sample 3 is consists of larger particle and less cohesive. Its natural (undisturbed) particle arrangement is weak and can sustain lower shear strength compared to its compacted sample. The compaction done to the soil caused it to be stronger from its original condition.

CHAPTER 4

CONCLUSION

4.1 Conclusion

At 25 blows per layer, remolded sample yields lower shear strength compared to undisturbed sample. This applied to four out of five soil samples tested using Triaxial Equipment. Damage of soil structure caused by sample disturbance is proven in decreasing the shear strength of soil. However different case applied to sample 3 that shows contradicting result. The undisturbed sample has higher shear strength values compared to remolded samples. It happens because Sample 3 consists of less cohesive soil, which is proven by its Particle Size Distribution.

4.2 Recommendation

At 25 blows per layer, remolded sample yields lower shear strength compared to undisturbed sample. It is suggested to increase the number of blows per layer in producing remolded sample for higher compactive effect for future research. At higher degree of compaction, it can be compared which sample yield higher shear strength

REFERENCES

[1] Norshakila Muhamad Rawai : Laboratory Study of Undrained Shear Strength of Pontian Clay: Comparison between Undisturbed and Remolded Sample

[2] Zhenshun Hong, Songyu Liu, Shuilong Shen and Takohito Nagami :Comparison in Undrained Shear Strength between Undisturbed and Remolded Ariake Clay

[3] Jiang, Hu, Peng, and Leroueil: Experimental Study of Two Saturated Natural Soils and Their Saturated Remoilded Soils under Three Consolidated Undrained Stress Path

[4] Merihun Lukas,: A Study on Effect of Remolding on The Mechanical Behavior of Addis Ababa Red Clay Soil

[5] Kamei, Tanaka and Hayashi : Comparison of Shear Characteristics of Undisturbed and Remolded Bangkok Clay.

[6] http://www.soiltestequipment.com/soil-compaction-test-%E2%80%93-degree-of-compaction-determination/

[7] http://en.wikipedia.org/wiki/Particle_size_distribution

[8] http://www.astm.org/Standards/D4318.htm

[9] http://en.wikipedia.org/wiki/Triaxial_shear_test

[10] http://www.epa.gov/athens/learn2model/part-two/onsite/mc.html

Location: Near Block 14

Moisture content

	Unit	1	2	3
Mass of wet soil + container (m_2)	g	34.81	50.74	31.43
Mass of dry soil + container (m_3)	g	31.84	47.06	29.12
Mass of container (m_1)	g	18.64	29.58	18.69
Mass of moisture ($m_2 - m_3$)	g	2.97	3.68	2.31
Mass of dry soil ($m_3 - m_1$)	g	13.2	17.48	10.43
MC, W	%	22.50	21.05	22.15
Average MC	%		22	

m_1= mass of container

m_2= mass of the wet soil+ container

m_3= mass of the dried soil + container

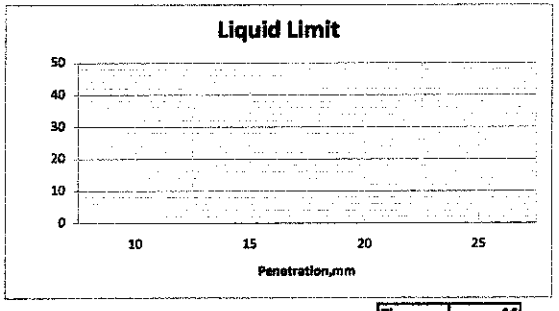
$$W = \frac{(m_2 - m_3)}{(m_3 - m_1)} \times 100\%$$

Plastic Limit

	Unit	1	2	3	4	5
Mass of wet soil + container (m_2)	g	23.1	24.2	22.5	22.4	22
Mass of dry soil + container (m_3)	g	22.25	23.58	21.8	21.72	21.47
Mass of container (m_1)	g	18.9	21	19	18.9	19
Mass of moisture ($m_2 - m_3$)	g	0.85	0.62	0.7	0.68	0.53
Mass of dry soil ($m_3 - m_1$)	g	3.35	2.58	2.8	2.82	2.47
MC, W	%	25.37	24.03	25.00	24.11	21.46
Average MC	%			24		

Liquid Limit (Cone Penetrometer Test)

	Unit	1	2	3	4
Mass of wet soil + container (m_2)	g	25.2	26.8	27.1	31.1
Mass of dry soil + container (m_3)	g	23.73	24.71	24.73	27.9
Mass of container (m_1)	g	19	19	18.9	20.5
Mass of moisture ($m_2 - m_3$)	g	1.47	2.09	2.37	3.2
Mass of dry soil ($m_3 - m_1$)	g	4.73	5.71	5.83	7.4
MC, W	%	31.08	36.60	40.65	43.24
Penetration	mm	12.25	18.15	21.15	24.90
Liquid Limit			38		



PI	14

Particle size distribution

Sieve size	Mass of sieve (g)	Mass of sieve+ soil retain (g)	Mass retained (g)	Percentage retained (%)	Percentage passing (%)
2 mm	469.06	655.11	186.05	19	81
1.18 mm	425.63	525.43	99.8	10	71
600 µm	403.16	520.12	116.96	12	60
425 µm	370.76	445.83	75.07	8	52
300 µm	355.8	462.47	106.67	11	42
212 µm	339.7	444.99	105.29	11	31
150 µm	333.54	427.71	94.17	9	22
63 µm	322.57	486.21	163.64	16	5
Passing 63 µm	393.87	445.5	51.63	5	0
		Σ	999.28	100	

Location: Near Block 13

Moisture content of sample 2

	Unit	1	2	3
Mass of wet soil + container (m_2)	g	37.44	19.45	30.78
Mass of dry soil + container (m_3)	g	35.36	17.7	29.17
Mass of container (m_1)	g	20.78	6.67	19.06
Mass of moisture ($m_2 - m_3$)	g	2.08	1.75	1.61
Mass of dry soil ($m_3 - m_1$)	g	14.58	11.03	10.11
MC, W	%	14.27	15.87	15.92
Average MC	%		15	

m_1= mass of container
m_2= mass of the wet soil+ container
m_3= mass of the dried soil + container

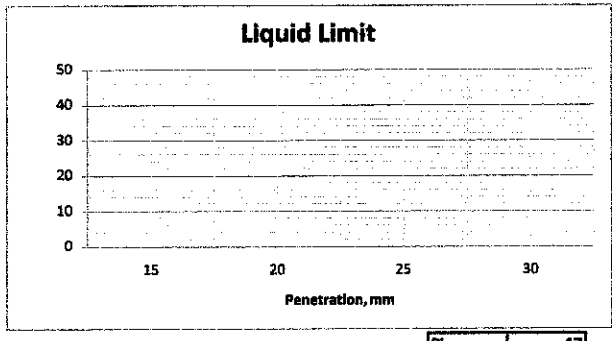
$$W = \frac{(m_2 - m_3)}{(m_3 - m_1)} \times 100\%$$

Plastic Limit

	Unit	1	2	3	4	5
Mass of wet soil + container (m_2)	g	20.9	21	21.4	21.1	23.3
Mass of dry soil + container (m_3)	g	20.5	20.7	21.1	20.8	23
Mass of container (m_1)	g	18.1	19.1	18.7	19.1	20.9
Mass of moisture ($m_2 - m_3$)	g	0.4	0.3	0.3	0.3	0.3
Mass of dry soil ($m_3 - m_1$)	g	2.4	1.6	2.4	1.7	2.1
MC, W	%	16.67	18.75	12.50	17.65	14.29
Average MC	%			16		

Liquid Limit (Cone Penetrometer Test)

	Unit	1	2	3
Mass of wet soil + container (m_2)	g	25.2	26.8	31.1
Mass of dry soil + container (m_3)	g	23.73	24.71	27.9
Mass of container (m_1)	g	18.1	19.1	20.5
Mass of moisture ($m_2 - m_3$)	g	1.47	2.09	3.2
Mass of dry soil ($m_3 - m_1$)	g	5.63	5.61	7.4
MC, W	%	26.11	37.25	43.24
Penetration	mm	14.90	23.60	28.50
Liquid Limit			33	



PI	17

Particle size distribution

Sieve size	Mass of sieve (g)	Mass of sieve+ soil retain (g)	Mass retained (g)	Percentage retained (%)	Percentage passing (%)
2 mm	469.47	564.87	95.4	19	81
1.18 mm	434.74	481.03	46.29	9	72
600 µm	405.78	455.43	49.65	10	62
425 µm	369.22	405.2	35.98	7	55
300 µm	358.44	417.05	58.61	12	43
212 µm	346.09	406.54	60.45	12	31
150 µm	311.21	362.26	51.05	10	21
63 µm	322.73	388.3	65.57	13	8
Passing 63 µm	393.91	432.35	38.44	8	0
		Σ	501.44	100	

Location: Near UTP lake

Moisture content of sample 3

	Unit	1	2	3
Mass of wet soil + container (m_2)	g	47.14	48.24	46.95
Mass of dry soil + container (m_3)	g	44.46	46.02	44.72
Mass of container (m_1)	g	18.22	19.06	18.73
Mass of moisture ($m_2 - m_3$)	g	2.68	2.22	2.23
Mass of dry soil ($m_3 - m_1$)	g	26.24	26.96	25.99
MC, W	%	10.21	8.23	8.58
Average MC	%		9	

m_1- mass of container

m_2- mass of the wet soil+ container

m_3- mass of the dried soil + container

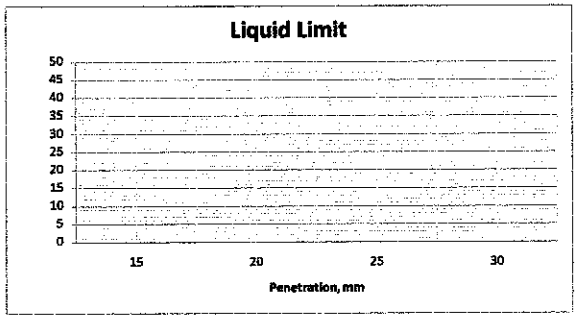
$$W = \frac{(m_2 - m_3)}{(m_3 - m_1)} \times 100\%$$

Plastic Limit

	Unit	1	2	3	4
Mass of wet soil + container (m_2)	g	21.6	23.5	23.5	22.4
Mass of dry soil + container (m_3)	g	21.12	22.98	23.03	22
Mass of container (m_1)	g	18.5	20.6	20.6	19.6
Mass of moisture ($m_2 - m_3$)	g	0.48	0.52	0.47	0.4
Mass of dry soil ($m_3 - m_1$)	g	2.62	2.38	2.43	2.4
MC, W	%	18.32	21.85	19.34	16.67
Average MC	%		19		

Liquid Limit (Cone Penetrometer Test)

	Unit	1	2	3	4
Mass of wet soil + container (m_2)	g	27.4	29.4	22.3	31.7
Mass of dry soil + container (m_3)	g	26.63	27.63	21.54	28.83
Mass of container (m_1)	g	20.5	20.5	18.5	19
Mass of moisture ($m_2 - m_3$)	g	0.77	1.77	0.76	2.87
Mass of dry soil ($m_3 - m_1$)	g	6.13	7.13	3.04	9.83
MC, W	%	22	24.82	25.00	29.20
Penetration	mm	15.7	20.10	24.10	35.00
Liquid Limit			24		



PI	5

Particle size distribution

Sieve size	Mass of sieve (g)	Mass of sieve+ soil retain (g)	Mass retained (g)	Percentage retained (%)	Percentage passing (%)
2 mm	469.82	587.22	117.4	23	77
1.18 mm	434.8	507.98	73.18	15	62
600 µm	404.86	496.61	91.75	18	44
425 µm	369.13	395.89	26.76	5	38
300 µm	358.36	391.37	33.01	7	32
212 µm	346.11	393.7	47.59	9	22
150 µm	311.25	354.23	42.98	9	14
63 µm	322.67	368.11	45.44	9	5
Passing 63 µm	393.83	416.86	23.03	5	0
		Σ	501.14	100	

Location: Jogging track (left)

Moisture content of sample 4

	Unit	1	2	3
Mass of wet soil + container (m_2)	g	40.04	45.36	44.8
Mass of dry soil + container (m_3)	g	35.52	39.94	39.73
Mass of container (m_1)	g	19.71	20.96	21.13
Mass of moisture ($m_2 - m_3$)	g	4.52	5.42	5.07
Mass of dry soil ($m_3 - m_1$)	g	15.81	18.98	18.6
MC, W	%	28.59	28.56	27.26
Average MC	%		28	

m_1= mass of container
m_2= mass of the wet soil+ container
m_3= mass of the dried soil + container

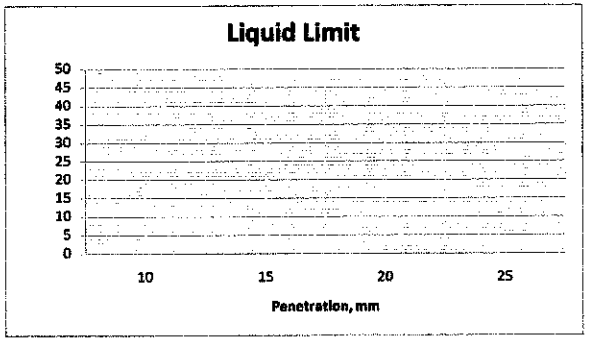
$$W = \frac{(m_2 - m_3)}{(m_3 - m_1)} \times 100\%$$

Plastic Limit

	Unit	1	2	3	4	5
Mass of wet soil + container (m_2)	g	22.7	23.8	23.3	21.8	23.2
Mass of dry soil + container (m_3)	g	21.8	23.1	22.8	21.2	22.5
Mass of container (m_1)	g	19.9	20.7	21.1	19.21	20.4
Mass of moisture ($m_2 - m_3$)	g	0.9	0.7	0.5	0.6	0.7
Mass of dry soil ($m_3 - m_1$)	g	1.9	2.4	1.7	1.99	2.1
MC, W	%	47.37	29.17	29.41	30.15	33.33
Average MC	%			34		

Liquid Limit (Cone Penetrometer Test)

	Unit	1	2	3
Mass of wet soil + container (m_2)	g	26.5	22.1	31.5
Mass of dry soil + container (m_3)	g	25	21.1	28.8
Mass of container (m_1)	g	21.1	19	23.3
Mass of moisture ($m_2 - m_3$)	g	1.5	1	2.7
Mass of dry soil ($m_3 - m_1$)	g	3.9	2.1	5.5
MC, W	%	38.46	47.62	49.09
Penetration	mm	13.00	17.00	23.10
Liquid Limit			47	



Pi	13

Particle size distribution

Sieve size	Mass of sieve (g)	Mass of sieve+ soil retain (g)	Mass retained (g)	Percentage retained (%)	Percentage passing (%)
2 mm	469.46	561.42	91.96	18	82
1.18 mm	425.92	509.18	83.26	17	65
600 µm	403.37	473.64	70.27	14	51
425 µm	370.8	404.34	33.54	7	44
300 µm	355.87	396	40.13	8	36
212 µm	339.75	379.66	39.91	8	28
150 µm	333.59	373.08	39.49	8	20
63 µm	323.02	410.24	87.22	17	3
Passing 63 µm	393.88	409.31	15.43	3	0
			Σ 501.21	100	

Location: Jogging track (right)

Moisture content of sample 5

	Unit	1	2	3
Mass of wet soil + container (m_2)	g	52.53	43.35	37.71
Mass of dry soil + container (m_3)	g	46.79	38.45	34.21
Mass of container (m_1)	g	21.26	19.1	19.06
Mass of moisture ($m_2 - m_3$)	g	5.74	4.9	3.5
Mass of dry soil ($m_3 - m_1$)	g	25.53	19.35	15.15
MC, W	%	22.48	25.32	23.10
Average MC	%		24	

m_1= mass of container
m_2= mass of the wet soil+ container
m_3= mass of the dried soil + container

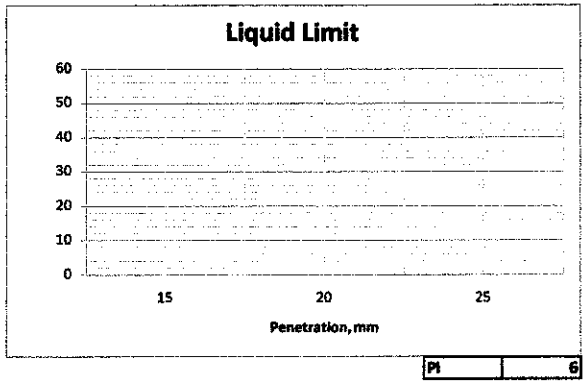
$$W = \frac{(m_2 - m_3)}{(m_3 - m_1)} \times 100\%$$

Plastic Limit

	Unit	1	2	3	4	5
Mass of wet soil + container (m_2)	g	24.3	21.8	22	23.4	21.3
Mass of dry soil + container (m_3)	g	23.7	21.3	21.5	22.9	20.8
Mass of container (m_1)	g	21.13	19.1	19.1	20.5	18.7
Mass of moisture ($m_2 - m_3$)	g	0.6	0.5	0.5	0.5	0.5
Mass of dry soil ($m_3 - m_1$)	g	2.57	2.2	2.4	2.4	2.1
MC, W	%	23.35	22.73	20.83	20.83	23.81
Average MC	%			22		

Liquid Limit (Cone Penetrometer Test)

	Unit	1	2	3
Mass of wet soil + container (m_2)	g	26.9	28.9	34.1
Mass of dry soil + container (m_3)	g	26	26.8	28.8
Mass of container (m_1)	g	20.8	21.1	19
Mass of moisture ($m_2 - m_3$)	g	0.9	2.1	5.3
Mass of dry soil ($m_3 - m_1$)	g	5.2	5.7	9.8
MC, W	%	17.31	36.84	54.08
Penetration	mm	17.10	23.00	29.00
Liquid Limit			28.5	



PI	6

Particle size distribution

Sieve size	Mass of sieve (g)	Mass of sieve+ soil retain (g)	Mass retained (g)	Percentage retained (%)	Percentage passing (%)
2 mm	469.82	551.71	81.89	16	84
1.18 mm	434.8	476.23	41.43	8	75
600 µm	404.86	457.6	52.74	10	65
425 µm	369.13	402.14	33.01	7	58
300 µm	358.36	407.28	48.92	10	49
212 µm	346.11	398.67	52.56	10	38
150 µm	311.25	363.61	52.36	10	28
63 µm	322.67	419.93	97.26	19	8
Passing 63 µm	393.83	436.3	42.47	8	0
		Σ	502.64	100	

Undrained Shear Strength in Triaxial Compression without measurement of Pore Pressure (Quick Undrained)

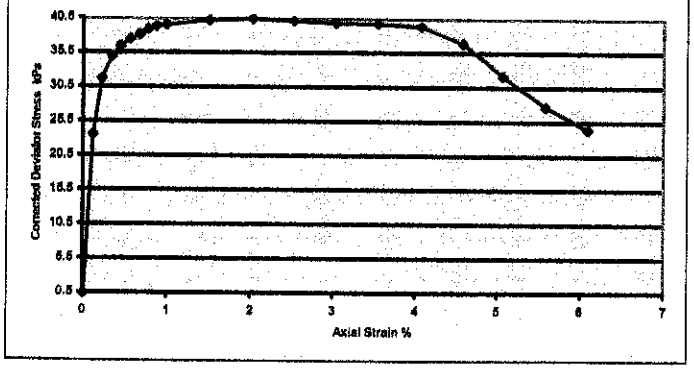
ELE International

Client	SAMPLE 1R	Ref	
Project		Job	1R
Borehole		Sample	1R

Test Details			
Standard	BS 1377 : Part 7 : Clause 8	Particle Density	2.65 Mg/m3
Sample Type			
Lab. Temperature	0.0 deg.C	Variations from procedure	

Specimen Details			
Specimen Reference	A1	Stage Reference	1
Depth within Sample	0.00mm	Description	
Initial Height	76.00 mm	Orientation within Sample	
Preparation		Initial Diameter	38.00 mm
Initial Bulk Density	0.00 Mg/m3	Initial Moisture Content	0.00 %
Initial Dry Density	2.26 Mg/m3	Membrane Thickness	0.20 mm
Comments			

Shearing Stage (Stress Vs Axial Strain %)



Undrained Shear Strength in Triaxial Compression without measurement of Pore Pressure (Quick Undrained)

ELE International

Client	SAMPLE 1R	Ref	
Project		Job	1R
Borehole		Sample	1R

Shear Conditions			
Rate of Axial Strain	2.03%/min	Cell Pressure	99.4kPa

Conditions at Failure			
Failure Criterion	Maximum Deviator Stress or Maximum allowed Strain		
Maximum Corrected Deviator Stress	40kPa	Shear Strength	20kPa
Axial Strain	2.02%		
Deviator Stress Correction	0.3 kPa		
Final Density	2.32 Mg/m3	Final Moisture Content	2.56 %

Mode of Failure

Tested By and Date:	
Checked By and Date:	
Approved By and Date:	

Undrained Shear Strength in Triaxial Compression without measurement of Pore Pressure (Quick Undrained)

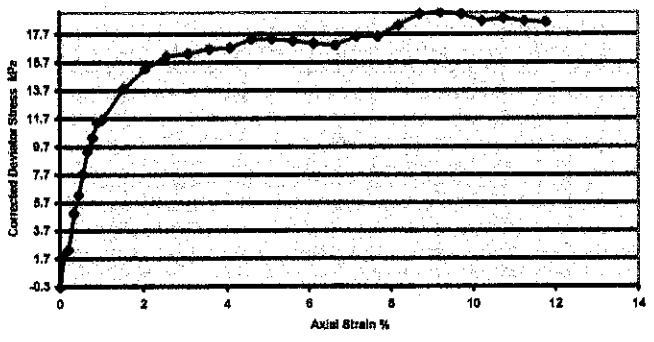
ELE International

Client	SAMPLE 1 R	Ref	
Project		Job	1
Borehole		Sample	1

Test Details			
Standard	BS 1377 : Part 7 : Clause 8	Particle Density	2.65 Mg/m3
Sample Type	Core sample		
Lab. Temperature	0.0 deg.C	Variations from procedure	

Specimen Details			
Specimen Reference	B1	Stage Reference	1
Depth within Sample	0.00mm	Description	
Initial Height	76.00 mm	Orientation within Sample	
Preparation		Initial Diameter	38.00 mm
Initial Bulk Density	0.00 Mg/m3	Initial Moisture Content	0.00 %
Initial Dry Density	2.28 Mg/m3	Membrane Thickness	0.20 mm
Comments			

Shearing Stage (Stress Vs Axial Strain %)



Undrained Shear Strength in Triaxial Compression without measurement of Pore Pressure (Quick Undrained)

ELE International

Client	SAMPLE 1 R	Ref	
Project		Job	1
Borehole		Sample	1

Shear Conditions			
Rate of Axial Strain	2.03%/min	Cell Pressure	200.1kPa

Conditions at Failure			
Failure Criterion	Maximum Deviator Stress or Maximum allowed Strain		
Maximum Corrected Deviator Stress	19kPa	Shear Strength	10kPa
Axial Strain	9.21%		
Deviator Stress Correction	1.2 kPa		
Final Density	2.32 Mg/m3	Final Moisture Content	2.56 %

Mode of Failure

Tested By and Date:	
Checked By and Date:	
Approved By and Date:	

Undrained Shear Strength in Triaxial Compression without measurement of Pore Pressure (Quick Undrained)

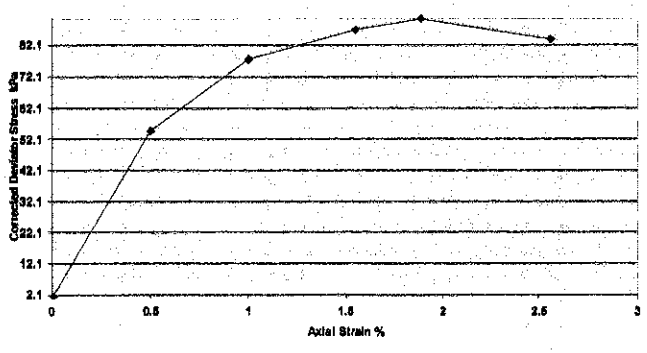
ELE International

Client	SAMPLE 1R	Ref	
Project		Job	1R
Borehole		Sample	1R

Test Details			
Standard	BS 1377 : Part 7 : Clause 8	Particle Density	2.65 Mg/m3
Sample Type			
Lab. Temperature	0.0 deg.C	Variations from procedure	

Specimen Details			
Specimen Reference	C1	Stage Reference	1
Depth within Sample	0.00mm	Description	
Initial Height	76.00 mm	Orientation within Sample	
Preparation		Initial Diameter	38.00 mm
Initial Bulk Density	0.00 Mg/m3	Initial Moisture Content	0.00 %
Initial Dry Density	2.32 Mg/m3	Membrane Thickness	0.20 mm
Comments			

Shearing Stage (Stress Vs Axial Strain %)



Generated by Foxit PDF Creator © Foxit Software
http://www.foxitsoftware.com For evaluation only.

Undrained Shear Strength in Triaxial Compression without measurement of Pore Pressure (Quick Undrained)

ELE International

Client	SAMPLE 1R	Ref	
Project		Job	1R
Borehole		Sample	1R

Shear Conditions			
Rate of Axial Strain	2.03%/min	Cell Pressure	399.6kPa

Conditions at Failure			
Failure Criterion	Maximum Deviator Stress or Maximum allowed Strain		
Maximum Corrected Deviator Stress	91kPa	Shear Strength	46kPa
Axial Strain	1.89%		
Deviator Stress Correction	0.1 kPa		
Final Density	2.36 Mg/m3	Final Moisture Content	1.50 %

Mode of Failure

Tested By and Date:	
Checked By and Date:	
Approved By and Date:	

SUMMARY

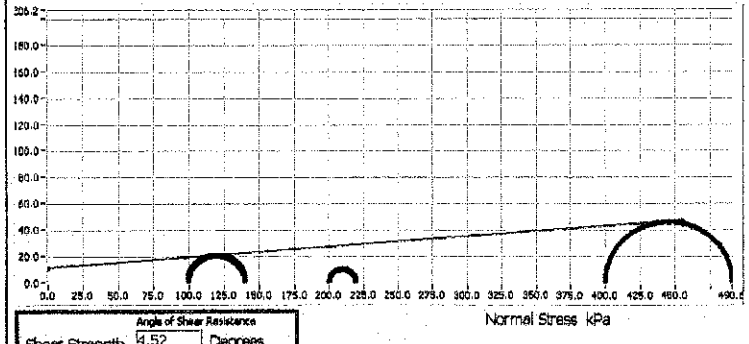
Undrained Shear Strength in Triaxial Compression without measurement of Pore Pressure (Quick Undrained)

ELE International

All Stages Conditions at Failure					
Ref	Cell Pressure	Max. Corrected Deviator Stress	Cumulative Strain	Mode of Failure	Shear Strength
Stage1	99.4kPa	40kPa	2.02%	Maximum Deviator Stress or Maximum allowed Strain	20kPa
Stage2	200.1kPa	19kPa	9.21%	Maximum Deviator Stress or Maximum allowed Strain	10kPa
Stage3	399.6kPa	91kPa	1.89%	Maximum Deviator Stress or Maximum allowed Strain	46kPa

Shear Stress kPa

Mohr Circles



Shear Strength Properties

Angle of Shear Resistance: 4.52 Degrees

Cohesion: 11.07 kPa

Undrained Shear Strength in Triaxial Compression without measurement of Pore Pressure (Quick Undrained)

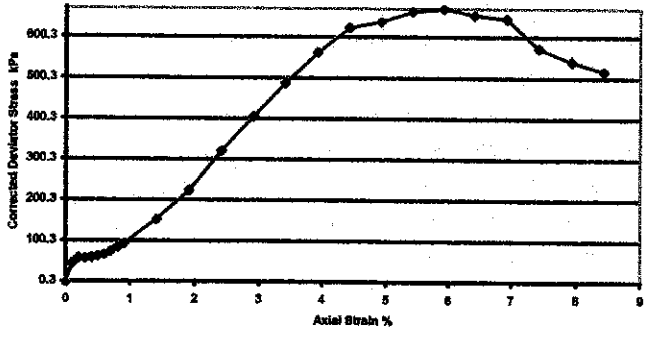
ELE International

Client	1UD	Ref	
Project		Job	1 UD
Borehole		Sample	1 UD

Test Details			
Standard	BS 1377 : Part 7 : Clause 8	Particle Density	2.65 Mg/m3
Sample Type			
Lab. Temperature	0.0 deg.C	Variations from procedure	

Specimen Details			
Specimen Reference	A1	Stage Reference	1
Depth within Sample	0.00mm	Description	
Initial Height	76.00 mm	Orientation within Sample	
Preparation		Initial Diameter	38.00 mm
Initial Bulk Density	2.78 Mg/m3	Initial Moisture Content	0.00 %
Initial Dry Density	2.26 Mg/m3	Membrane Thickness	0.20 mm
Comments			

Shearing Stage (Stress Vs Axial Strain %)



Undrained Shear Strength in Triaxial Compression without measurement of Pore Pressure (Quick Undrained)

ELE International

Client	1 UD	Ref	
Project		Job	1 UD
Borehole		Sample	1 UD

Shear Conditions			
Rate of Axial Strain	2.03%/min	Cell Pressure	99.8kPa

Conditions at Failure			
Failure Criterion	Maximum Deviator Stress or Maximum allowed Strain		
Maximum Corrected Deviator Stress	97kPa	Shear Strength	48kPa
Axial Strain	0.91%		
Deviator Stress Correction	0.1 kPa		
Final Density	2.32 Mg/m3	Final Moisture Content	2.56 %

Mode of Failure

Tested By and Date:	
Checked By and Date:	
Approved By and Date:	

Client	1UD	Ref	
Project		Job	1 UD

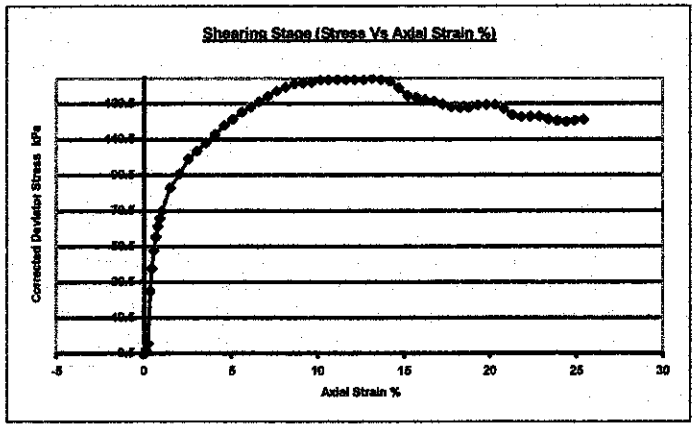
Undrained Shear Strength in Triaxial Compression without measurement of Pore Pressure (Quick Undrained)

ELE International

Borehole		Sample	1 UD

Test Details			
Standard	BS 1377 : Part 7 : Clause 8	Particle Density	2.65 Mg/m3
Sample Type	Core sample		
Lab. Temperature	0.0 deg.C	Variations from procedure	

Specimen Details			
Specimen Reference	B1	Stage Reference	1
Depth within Sample	0.00mm	Description	
Initial Height	76.00 mm	Orientation within Sample	
Preparation		Initial Diameter	38.00 mm
Initial Bulk Density	0.00 Mg/m3	Initial Moisture Content	0.00 %
Initial Dry Density	2.26 Mg/m3	Membrane Thickness	0.20 mm
Comments			



Undrained Shear Strength in Triaxial Compression without measurement of Pore Pressure (Quick Undrained)

ELE International

Client	1 UD	Ref	
Project		Job	1 UD
Borehole		Sample	1 UD

Shear Conditions			
Rate of Axial Strain	2.03%/min	Cell Pressure	200.2kPa

Conditions at Failure			
Failure Criterion	Maximum Deviator Stress or Maximum allowed Strain		
Maximum Corrected Deviator Stress	154kPa	Shear Strength	77kPa
Axial Strain	11.66%		
Deviator Stress Correction	1.4 kPa		
Final Density	2.44 Mg/m3	Final Moisture Content	7.69 %

Mode of Failure

Tested By and Date:	
Checked By and Date:	
Approved By and Date:	

Client	1 UD	Ref	
Project		Job	1 UD

Undrained Shear Strength in Triaxial Compression without measurement of Pore Pressure (Quick Undrained)

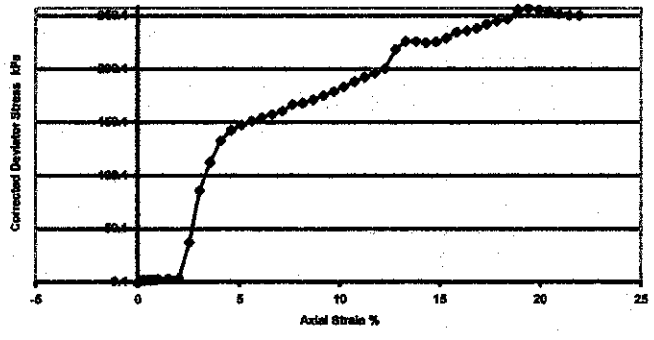
ELE International

Borehole		Sample	1 UD

Test Details			
Standard	BS 1377 : Part 7 : Clause 8	Particle Density	2.65 Mg/m3
Sample Type			
Lab. Temperature	0.0 deg.C	Variations from procedure	

Specimen Details			
Specimen Reference	C1	Stage Reference	1
Depth within Sample	0.00mm	Description	
Initial Height	76.00 mm	Orientation within Sample	
Preparation		Initial Diameter	38.00 mm
Initial Bulk Density	0.00 Mg/m3	Initial Moisture Content	0.00 %
Initial Dry Density	2.27 Mg/m3	Membrane Thickness	0.20 mm
Comments			

Shearing Stage (Stress Vs Axial Strain %)



Generated by Foxit PDF Creator © Foxit Software
http://www.foxitsoftware.com For evaluation only.

Undrained Shear Strength in Triaxial Compression without measurement of Pore Pressure (Quick Undrained)

ELE International

Client	1 UD	Ref	
Project		Job	1 UD
Borehole		Sample	1 UD

Shear Conditions			
Rate of Axial Strain	2.03%/min	Cell Pressure	399.9kPa

Conditions at Failure			
Failure Criterion	Maximum Deviator Stress or Maximum allowed Strain		
Maximum Corrected Deviator Stress	258kPa	Shear Strength	129kPa
Axial Strain	19.41%		
Deviator Stress Correction	2.0 kPa		
Final Density	237.84 Mg/m3	Final Moisture Content	10359.18 %

Mode of Failure

Tested By and Date:	
Checked By and Date:	
Approved By and Date:	

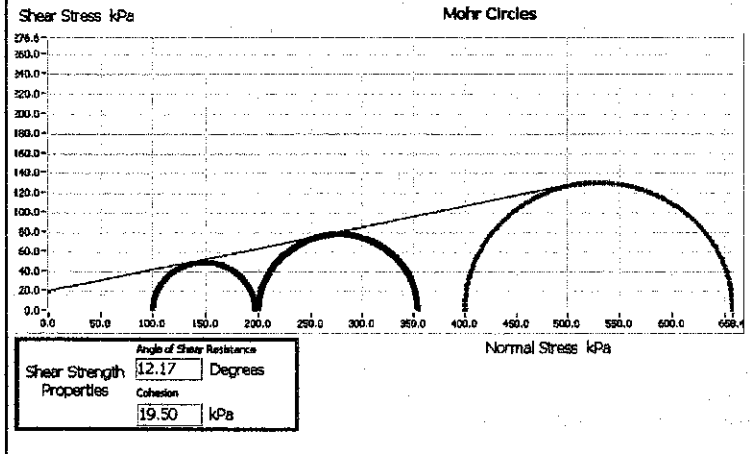
SUMMARY

Undrained Shear Strength In Triaxial Compression without measurement of Pore Pressure (Quick Undrained)

ELE International

All Stages
Conditions at Failure

Ref	Cell Pressure	Max. Corrected Deviator Stress	Cumulative Strain	Mode of Failure	Shear Strength
Stage1	99.8kPa	97kPa	6.01%	Maximum Deviator Stress or Maximum allowed Strain	48kPa
Stage2	200.2kPa	154kPa	11.66%	Maximum Deviator Stress or Maximum allowed Strain	77kPa
Stage3	399.9kPa	258kPa	19.41%	Maximum Deviator Stress or Maximum allowed Strain	129kPa



Shear Strength Properties
Angle of Shear Resistance 12.17 Degrees
Cohesion 19.50 kPa

Undrained Shear Strength in Triaxial Compression without measurement of Pore Pressure (Quick Undrained)

ELE International

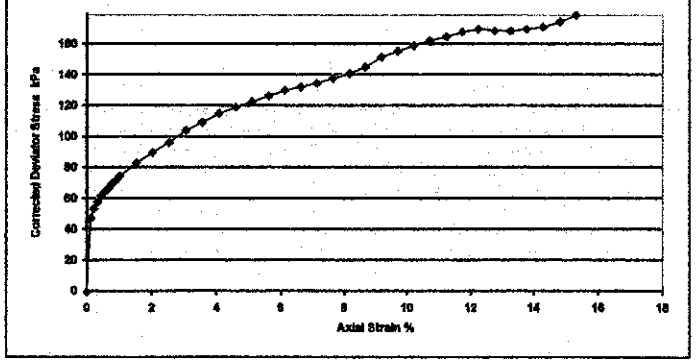
Client	SAMPLE 2 R	Lab Ref	
Project		Job	2R
Borehole		Sample	2R

Test Details			
Standard	BS 1377 : Part 7 : Clause 8	Particle Density	2.65 Mg/m3
Sample Type	Core sample	Lab. Temperature	0.0 deg.C
Sample Description			
Variations from Procedure	None		

Specimen Details			
Specimen Reference	A1	Stage Reference	1
Depth within Sample	0.00mm	Description	
Initial Height	76.00 mm	Orientation within Sample	
Preparation		Initial Diameter	38.00 mm
Initial Bulk Density	0.00 Mg/m3	Initial Moisture Content*	-100.0 %
Initial Dry Density	2.34 Mg/m3	Membrane Thickness	0.20 mm
Comments			

* Calculated from initial and dry weights of whole specimen

Shearing Stage (Stress Vs Axial Strain %)



Generated by Foxit PDF Creator © Foxit Software
http://www.foxitsoftware.com For evaluation only.

Undrained Shear Strength in Triaxial Compression without measurement of Pore Pressure (Quick Undrained)

ELE International

Client	SAMPLE 2 R	Lab Ref	
Project		Job	2R
Borehole		Sample	2R

Shear Conditions			
Rate of Axial Strain	2.03%/min	Cell Pressure	99.8kPa

Conditions at Failure			
Failure Criterion	Maximum Deviator Stress or Maximum allowed Strain		
Maximum Corrected Deviator Stress	170kPa	Shear Strength	85kPa
Axial Strain	12.24%		
Deviator Stress Correction	1.4 kPa		
Final Density	2.36 Mg/m3	Final Moisture Content	0.5 %

Tested By and Date:	
Checked By and Date:	
Approved By and Date:	

Mode of Failure

Undrained Shear Strength in Triaxial Compression without measurement of Pore Pressure (Quick Undrained)

ELE International

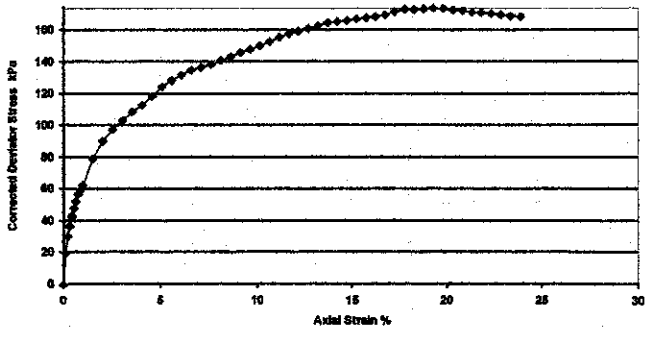
Client	SAMPLE 2R	Lab Ref	
Project		Job	2R
Borehole		Sample	2R

Test Details			
Standard	BS 1377 : Part 7 : Clause 8	Particle Density	2.65 Mg/m3
Sample Type	Core sample	Lab. Temperature	0.0 deg.C
Sample Description			
Variations from Procedure	None		

Specimen Details			
Specimen Reference	B1	Stage Reference	1
Depth within Sample	0.00mm	Description	
Initial Height	76.00 mm	Orientation within Sample	
Preparation		Initial Diameter	38.00 mm
Initial Bulk Density	0.00 Mg/m3	Initial Moisture Content*	-100.0 %
Initial Dry Density	2.32 Mg/m3	Membrane Thickness	0.20 mm
Comments			

* Calculated from initial and dry weights of whole specimen

Shearing Stage (Stress Vs Axial Strain %)



Generated by Foxit PDF Creator © Foxit Software
http://www.foxitsoftware.com For evaluation only.

Undrained Shear Strength in Triaxial Compression without measurement of Pore Pressure (Quick Undrained)

ELE International

Client	SAMPLE 2R	Lab Ref	
Project		Job	2R
Borehole		Sample	2R

Shear Conditions			
Rate of Axial Strain	2.03%/min	Cell Pressure	200.2kPa

Conditions at Failure			
Failure Criterion	Maximum Deviator Stress or Maximum allowed Strain		
Maximum Corrected Deviator Stress	174kPa	Shear Strength	87kPa
Axial Strain	19.30%		
Deviator Stress Correction	1.9 kPa		
Final Density	2.37 Mg/m3	Final Moisture Content	2.0 %

Mode of Failure

Tested By and Date:	
Checked By and Date:	
Approved By and Date:	

Undrained Shear Strength in Triaxial Compression without measurement of Pore Pressure (Quick Undrained)

ELE International

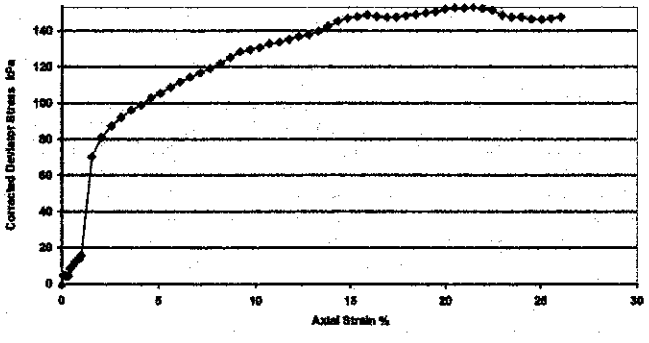
Client	SAMPLE 2 R	Lab Ref	
Project		Job	2R
Borehole		Sample	2R

Test Details			
Standard	BS 1377 : Part 7 : Clause 8	Particle Density	2.65 Mg/m3
Sample Type	Core sample	Lab. Temperature	0.0 deg.C
Sample Description			
Variations from Procedure	None		

Specimen Details			
Specimen Reference	C1	Stage Reference	1
Depth within Sample	0.00mm	Description	
Initial Height	76.00 mm	Orientation within Sample	
Preparation		Initial Diameter	38.00 mm
Initial Bulk Density	0.00 Mg/m3	Initial Moisture Content*	-100.0 %
Initial Dry Density	2.32 Mg/m3	Membrane Thickness	0.20 mm
Comments			

* Calculated from initial and dry weights of whole specimen

Shearing Stage (Stress Vs Axial Strain %)



Undrained Shear Strength in Triaxial Compression without measurement of Pore Pressure (Quick Undrained)

ELE International

Client	SAMPLE 2 R	Lab Ref	
Project		Job	2R
Borehole		Sample	2R

Shear Conditions			
Rate of Axial Strain	2.03%/min	Cell Pressure	400.4kPa

Conditions at Failure			
Failure Criterion	Maximum Deviator Stress or Maximum allowed Strain		
Maximum Corrected Deviator Stress	154kPa	Shear Strength	77kPa
Axial Strain	21.47%		
Deviator Stress Correction	2.0 kPa		
Final Density	2.37 Mg/m3	Final Moisture Content	2.0 %

Mode of Failure

Tested By and Date:	
Checked By and Date:	
Approved By and Date:	

SUMMARY

Undrained Shear Strength in Triaxial Compression without measurement of Pore Pressure (Quick Undrained)

ELE International

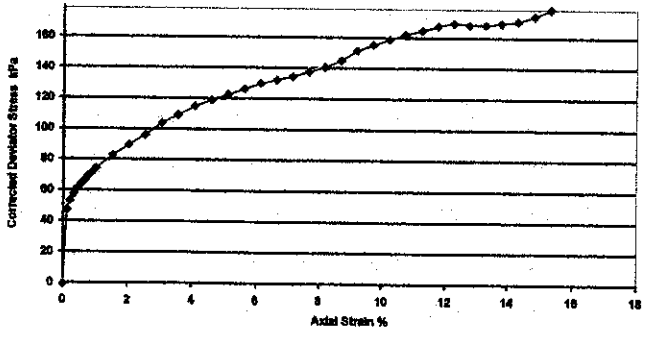
Client	SAMPLE 2 R	Lab Ref	
Project		Job	2R
Borehole		Sample	2R

Test Details			
Standard	BS 1377 : Part 7 : Clause 8	Particle Density	2.65 Mg/m3
Sample Type	Core sample	Lab. Temperature	0.0 deg.C
Sample Description			
Variations from Procedure	None		

Specimen Details			
Specimen Reference	A1	Stage Reference	1
Depth within Sample	0.00mm	Description	
Initial Height	76.00 mm	Orientation within Sample	
Preparation		Initial Diameter	38.00 mm
Initial Bulk Density	0.00 Mg/m3	Initial Moisture Content*	-100.0 %
Initial Dry Density	2.34 Mg/m3	Membrane Thickness	0.20 mm
Comments			

* Calculated from initial and dry weights of whole specimen

Shearing Stage (Stress Vs Axial Strain %)



Undrained Shear Strength in Triaxial Compression without measurement of Pore Pressure (Quick Undrained)

ELE International

Client	SAMPLE 2 R	Lab Ref	
Project		Job	2R
Borehole		Sample	2R

Shear Conditions			
Rate of Axial Strain	2.03%/min	Cell Pressure	99.8kPa

Conditions at Failure			
Failure Criterion	Maximum Deviator Stress or Maximum allowed Strain		
Maximum Corrected Deviator Stress	170kPa	Shear Strength	85kPa
Axial Strain	12.24%		
Deviator Stress Correction	1.4 kPa		
Final Density	2.36 Mg/m3	Final Moisture Content	0.5 %

Tested By and Date:	
Checked By and Date:	
Approved By and Date:	

Mode of Failure

Undrained Shear Strength In Triaxial Compression without measurement of Pore Pressure (Quick Undrained)

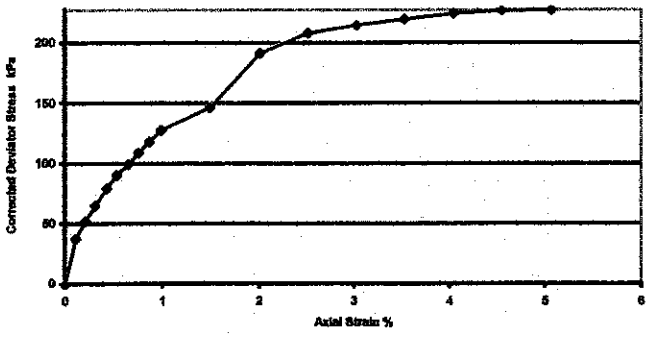
ELE International

Client	2UD	Ref	
Project		Job	2UD
Borehole		Sample	2UD

Test Details			
Standard	BS 1377 : Part 7 : Clause 8	Particle Density	2.65 Mg/m3
Sample Type			
Lab. Temperature	0.0 deg.C	Variations from procedure	

Specimen Details			
Specimen Reference	A1	Stage Reference	1
Depth within Sample	0.00mm	Description	
Initial Height	76.00 mm	Orientation within Sample	
Preparation		Initial Diameter	38.00 mm
Initial Bulk Density	0.00 Mg/m3	Initial Moisture Content	0.00 %
Initial Dry Density	2.26 Mg/m3	Membrane Thickness	0.20 mm
Comments			

Shearing Stage (Stress Vs Axial Strain %)



Generated by Foxit PDF Creator © Foxit Software
http://www.foxitsoftware.com For evaluation only.

Undrained Shear Strength In Triaxial Compression without measurement of Pore Pressure (Quick Undrained)

ELE International

Client	2UD	Ref	
Project		Job	2UD
Borehole		Sample	2UD

Shear Conditions			
Rate of Axial Strain	2.03%/min	Cell Pressure	99.0kPa

Conditions at Failure			
Failure Criterion	Maximum Deviator Stress or Maximum allowed Strain		
Maximum Corrected Deviator Stress	228kPa	Shear Strength	114kPa
Axial Strain	5.07%		
Deviator Stress Correction	0.7 kPa		
Final Density	2.32 Mg/m3	Final Moisture Content	2.56 %

Mode of Failure

Tested By and Date:	
Checked By and Date:	
Approved By and Date:	

Undrained Shear Strength in Triaxial Compression without measurement of Pore Pressure (Quick Undrained)

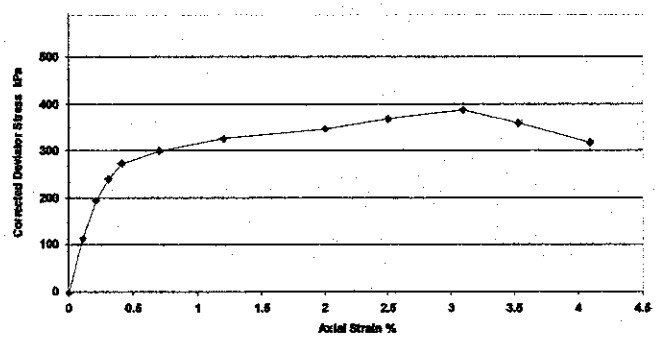
ELE International

Client	2UD	Ref	
Project		Job	2UD
Borehole		Sample	2UD

Test Details			
Standard	BS 1377 : Part 7 : Clause 8	Particle Density	2.65 Mg/m3
Sample Type			
Lab. Temperature	0.0 deg.C	Variations from procedure	

Specimen Details			
Specimen Reference	B1	Stage Reference	1
Depth within Sample	0.00mm	Description	
Initial Height	76.00 mm	Orientation within Sample	
Preparation		Initial Diameter	38.00 mm
Initial Bulk Density	0.00 Mg/m3	Initial Moisture Content	0.00 %
Initial Dry Density	2.30 Mg/m3	Membrane Thickness	0.20 mm
Comments			

Shearing Stage (Stress Vs Axial Strain %)



Undrained Shear Strength in Triaxial Compression without measurement of Pore Pressure (Quick Undrained)

ELE International

Client	2UD	Ref	
Project		Job	2UD
Borehole		Sample	2UD

Shear Conditions			
Rate of Axial Strain	2.03%/min	Cell Pressure	199.3kPa

Conditions at Failure			
Failure Criterion	Maximum Deviator Stress or Maximum allowed Strain		
Maximum Corrected Deviator Stress	389kPa	Shear Strength	195kPa
Axial Strain	0.92%		
Deviator Stress Correction	0.1 kPa		
Final Density	2.32 Mg/m3	Final Moisture Content	1.01 %

Mode of Failure

Tested By and Date:	
Checked By and Date:	
Approved By and Date:	

Undrained Shear Strength in Triaxial Compression without measurement of Pore Pressure (Quick Undrained)

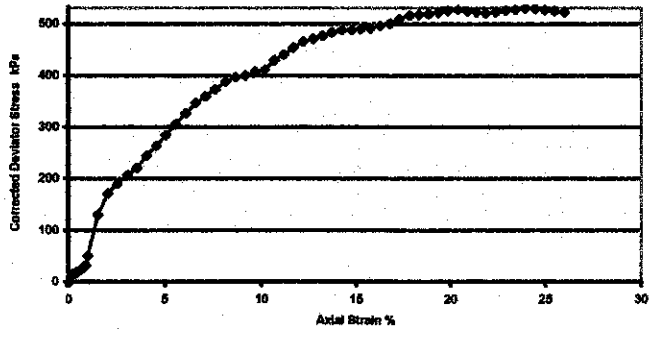
ELE International

Client	SAMPLE 2 UD	Ref	
Project		Job	2UD
Borehole		Sample	2UD

Test Details			
Standard	BS 1377 : Part 7 : Clause 8	Particle Density	2.65 Mg/m3
Sample Type			
Lab. Temperature	0.0 deg.C	Variations from procedure	

Specimen Details			
Specimen Reference	C1	Stage Reference	1
Depth within Sample	0.00mm	Description	
Initial Height	76.00 mm	Orientation within Sample	
Preparation		Initial Diameter	38.00 mm
Initial Bulk Density	0.00 Mg/m3	Initial Moisture Content	0.00 %
Initial Dry Density	2.26 Mg/m3	Membrane Thickness	0.20 mm
Comments			

Shearing Stage (Stress Vs Axial Strain %)



Undrained Shear Strength in Triaxial Compression without measurement of Pore Pressure (Quick Undrained)

ELE International

Client	SAMPLE 2 UD	Ref	
Project		Job	2
Borehole		Sample	2

Shear Conditions			
Rate of Axial Strain	2.03%/min	Cell Pressure	399.9kPa

Conditions at Failure			
Failure Criterion	Maximum Deviator Stress or Maximum allowed Strain		
Maximum Corrected Deviator Stress	530kPa	Shear Strength	265kPa
Axial Strain	20.39%		
Deviator Stress Correction	2.0 kPa		
Final Density	2.32 Mg/m3	Final Moisture Content	2.56 %

Mode of Failure

Tested By and Date:	
Checked By and Date:	
Approved By and Date:	

SUMMARY

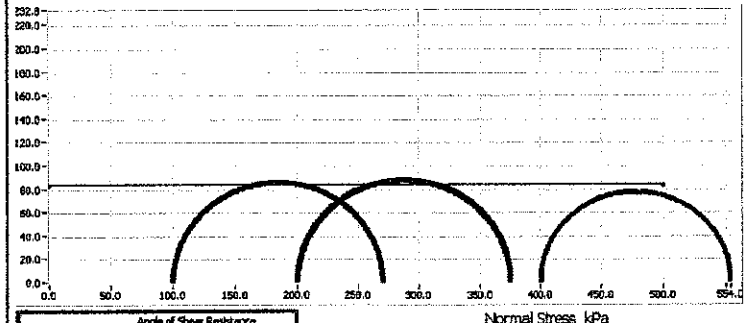
Undrained Shear Strength in Triaxial Compression without measurement of Pore Pressure (Quick Undrained)

ELE International

All Stages
Conditions at Failure

Ref	Cell Pressure	Max. Corrected Deviator Stress	Cumulative Strain	Mode of Failure	Shear Strength
Stage1	99.8kPa	170kPa	12.24%	Maximum Deviator Stress or Maximum allowed Strain	85kPa
Stage2	200.2kPa	174kPa	19.30%	Maximum Deviator Stress or Maximum allowed Strain	87kPa
Stage3	400.4kPa	154kPa	21.47%	Maximum Deviator Stress or Maximum allowed Strain	77kPa

Mohr Circles



Shear Strength Properties
Angle of Shear Resistance 0.00 Degrees
Cohesion 83.58 kPa

Undrained Shear Strength in Triaxial Compression without measurement of Pore Pressure (Quick Undrained)

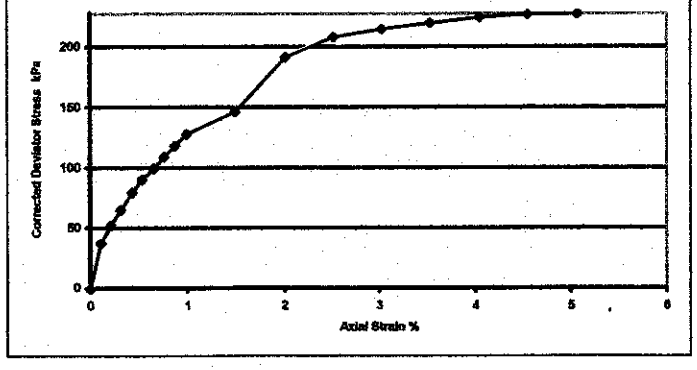
ELE International

Client	3R	Ref	
Project		Job	3R
Borehole		Sample	3R

Test Details			
Standard	BS 1377 : Part 7 : Clause 8	Particle Density	2.65 Mg/m3
Sample Type			
Lab. Temperature	0.0 deg.C	Variations from procedure	

Specimen Details			
Specimen Reference	A1	Stage Reference	1
Depth within Sample	0.00mm	Description	
Initial Height	76.00 mm	Orientation within Sample	
Preparation		Initial Diameter	38.00 mm
Initial Bulk Density	0.00 Mg/m3	Initial Moisture Content	0.00 %
Initial Dry Density	2.28 Mg/m3	Membrane Thickness	0.20 mm
Comments			

Shearing Stage (Stress Vs Axial Strain %)



Undrained Shear Strength in Triaxial Compression without measurement of Pore Pressure (Quick Undrained)

ELE International

Client	3R	Ref	
Project		Job	3R
Borehole		Sample	3R

Shear Conditions			
Rate of Axial Strain	2.03%/min	Cell Pressure	99.0kPa

Conditions at Failure			
Failure Criterion	Maximum Deviator Stress or Maximum allowed Strain		
Maximum Corrected Deviator Stress	228kPa	Shear Strength	114kPa
Axial Strain	5.07%		
Deviator Stress Correction	0.7 kPa		
Final Density	2.32 Mg/m3	Final Moisture Content	2.56 %

Mode of Failure

Tested By and Date:	
Checked By and Date:	
Approved By and Date:	

Undrained Shear Strength in Triaxial Compression without measurement of Pore Pressure (Quick Undrained)

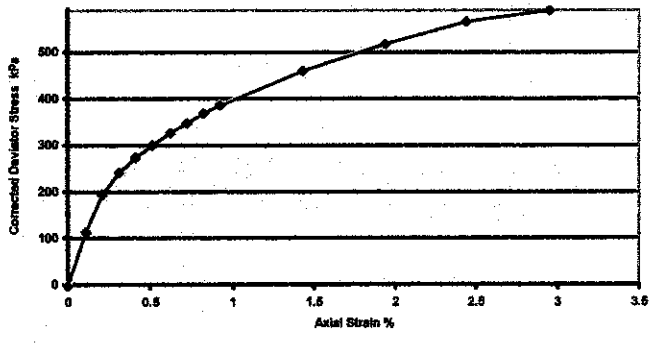
ELE International

Client	3R	Ref	
Project		Job	3R
Borehole		Sample	3R

Test Details			
Standard	BS 1377 : Part 7 : Clause 8	Particle Density	2.65 Mg/m3
Sample Type			
Lab. Temperature	0.0 deg.C	Variations from procedure	

Specimen Details			
Specimen Reference	B1	Stage Reference	1
Depth within Sample	0.00mm	Description	
Initial Height	76.00 mm	Orientation within Sample	
Preparation		Initial Diameter	38.00 mm
Initial Bulk Density	0.00 Mg/m3	Initial Moisture Content	0.00 %
Initial Dry Density	2.26 Mg/m3	Membrane Thickness	0.20 mm
Comments			

Shearing Stage (Stress Vs Axial Strain %)



Generated by Foxit PDF Creator © Foxit Software
http://www.foxitsoftware.com For evaluation only.

Undrained Shear Strength in Triaxial Compression without measurement of Pore Pressure (Quick Undrained)

ELE International

Client	3R	Ref	
Project		Job	3R
Borehole		Sample	3R

Shear Conditions			
Rate of Axial Strain	2.03%/min	Cell Pressure	199.2kPa

Conditions at Failure			
Failure Criterion	Maximum Deviator Stress or Maximum allowed Strain		
Maximum Corrected Deviator Stress	593kPa	Shear Strength	297kPa
Axial Strain	2.95%		
Deviator Stress Correction	0.4 kPa		
Final Density	2.32 Mg/m3	Final Moisture Content	2.56 %

Tested By and Date:	
Checked By and Date:	
Approved By and Date:	

Mode of Failure

Undrained Shear Strength in Triaxial Compression without measurement of Pore Pressure (Quick Undrained)

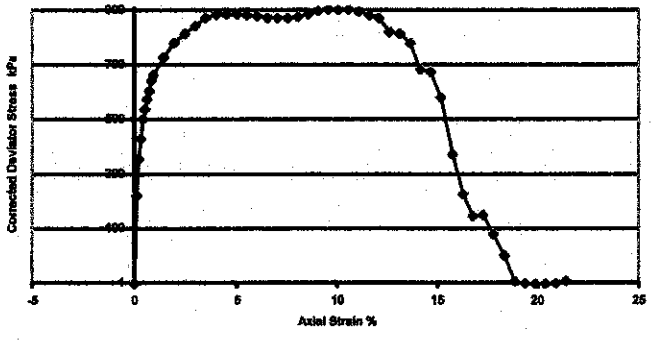
ELE International

Client	3R	Ref	
Project		Job	3R
Borehole		Sample	3R

Test Details			
Standard	BS 1377 : Part 7 : Clause 8	Particle Density	2.65 Mg/m3
Sample Type			
Lab. Temperature	0.0 deg.C	Variations from procedure	

Specimen Details			
Specimen Reference	C1	Stage Reference	1
Depth within Sample	0.00mm	Description	
Initial Height	76.00 mm	Orientation within Sample	
Preparation		Initial Diameter	38.00 mm
Initial Bulk Density	0.00 Mg/m3	Initial Moisture Content	0.00 %
Initial Dry Density	2.26 Mg/m3	Membrane Thickness	0.20 mm
Comments			

Shearing Stage (Stress Vs Axial Strain %)



Generated by Foxit PDF Creator © Foxit Software
http://www.foxitsoftware.com For evaluation only.

Undrained Shear Strength in Triaxial Compression without measurement of Pore Pressure (Quick Undrained)

ELE International

Client	3R	Ref	
Project		Job	3R
Borehole		Sample	3R

Shear Conditions			
Rate of Axial Strain	2.03%/min	Cell Pressure	400.8kPa

Conditions at Failure			
Failure Criterion	Maximum Deviator Stress or Maximum allowed Strain		
Maximum Corrected Deviator Stress	988kPa	Shear Strength	494kPa
Axial Strain	4.48%		
Deviator Stress Correction	0.6 kPa		
Final Density	2.32 Mg/m3	Final Moisture Content	2.56 %

Mode of Failure

Tested By and Date:	
Checked By and Date:	
Approved By and Date:	

SUMMARY

Undrained Shear Strength in Triaxial Compression without measurement of Pore Pressure (Quick Undrained)

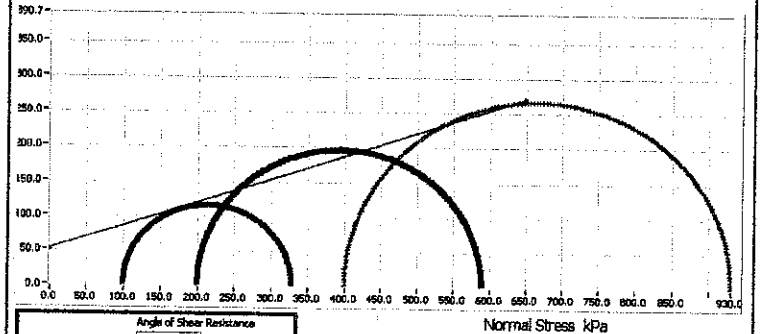
ELE International

All Stages
Conditions at Failure

Ref	Cell Pressure	Max. Corrected Deviator Stress	Cumulative Strain	Mode of Failure	Shear Strength
Stage1	99.0kPa	228kPa	5.07%	Maximum Deviator Stress or Maximum allowed Strain	114kPa
Stage2	199.3kPa	389kPa	3.06%	Maximum Deviator Stress or Maximum allowed Strain	195kPa
Stage3	399.9kPa	530kPa	20.39%	Maximum Deviator Stress or Maximum allowed Strain	265kPa

Shear Stress kPa

Mohr Circles



Shear Strength Properties

Angle of Shear Resistance: 18.58 Degrees

Cohesion: 51.14 kPa

Undrained Shear Strength in Triaxial Compression without measurement of Pore Pressure (Quick Undrained)

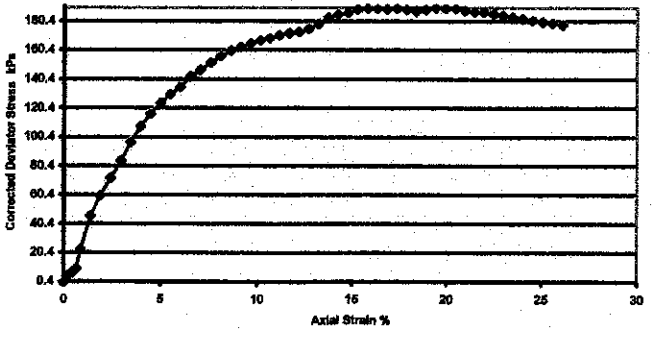
ELE International

Client	3UD	Ref	
Project		Job	3UD
Borehole		Sample	3UD

Test Details			
Standard	BS 1377 : Part 7 : Clause 8	Particle Density	2.65 Mg/m3
Sample Type			
Lab. Temperature	0.0 deg.C	Variations from procedure	

Specimen Details			
Specimen Reference	A1	Stage Reference	1
Depth within Sample	0.00mm	Description	
Initial Height	76.00 mm	Orientation within Sample	
Preparation		Initial Diameter	38.00 mm
Initial Bulk Density	0.00 Mg/m3	Initial Moisture Content	0.00 %
Initial Dry Density	2.90 Mg/m3	Membrane Thickness	0.20 mm
Comments			

Shearing Stage (Stress Vs Axial Strain %)



Generated by Foxit PDF Creator © Foxit Software
http://www.foxitsoftware.com For evaluation only.

Undrained Shear Strength in Triaxial Compression without measurement of Pore Pressure (Quick Undrained)

ELE International

Client	3UD	Ref	
Project		Job	3UD
Borehole		Sample	3UD

Shear Conditions			
Rate of Axial Strain	2.03%/min	Cell Pressure	99.8kPa

Conditions at Failure			
Failure Criterion	Maximum Deviator Stress or Maximum allowed Strain		
Maximum Corrected Deviator Stress	190kPa	Shear Strength	95kPa
Axial Strain	16.32%		
Deviator Stress Correction	1.7 kPa		
Final Density	3.48 Mg/m3	Final Moisture Content	20.00 %

Mode of Failure

Tested By and Date:	25/1/2011
Checked By and Date:	
Approved By and Date:	

Undrained Shear Strength in Triaxial Compression without measurement of Pore Pressure (Quick Undrained)

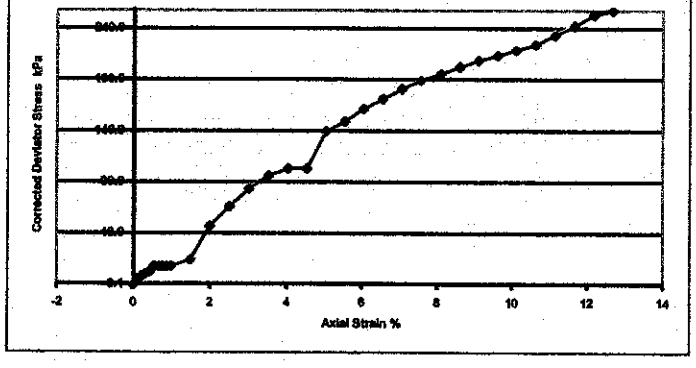
ELE International

Client	3UD	Ref	
Project		Job	3UD
Borehole		Sample	3UD

Test Details			
Standard	BS 1377 : Part 7 : Clause 8	Particle Density	2.65 Mg/m3
Sample Type			
Lab. Temperature	0.0 deg.C	Variations from procedure	

Specimen Details			
Specimen Reference	B1	Stage Reference	1
Depth within Sample	0.00mm	Description	
Initial Height	76.00 mm	Orientation within Sample	
Preparation		Initial Diameter	38.00 mm
Initial Bulk Density	0.00 Mg/m3	Initial Moisture Content	0.00 %
Initial Dry Density	2.27 Mg/m3	Membrane Thickness	0.20 mm
Comments			

Shearing Stage (Stress Vs Axial Strain %)



Generated by Foxit PDF Creator © Foxit Software
http://www.foxitsoftware.com For evaluation only.

Undrained Shear Strength in Triaxial Compression without measurement of Pore Pressure (Quick Undrained)

ELE International

Client	3UD	Ref	
Project		Job	3UD
Borehole		Sample	3UD

Shear Conditions			
Rate of Axial Strain	2.03%/min	Cell Pressure	198.0kPa

Conditions at Failure			
Failure Criterion	Maximum Deviator Stress or Maximum allowed Strain		
Maximum Corrected Deviator Stress	268kPa	Shear Strength	134kPa
Axial Strain	12.67%		
Deviator Stress Correction	1.5 kPa		
Final Density	2.32 Mg/m3	Final Moisture Content	2.04 %

Mode of Failure

Tested By and Date:	
Checked By and Date:	
Approved By and Date:	

Undrained Shear Strength in Triaxial Compression without measurement of Pore Pressure (Quick Undrained)

ELE International

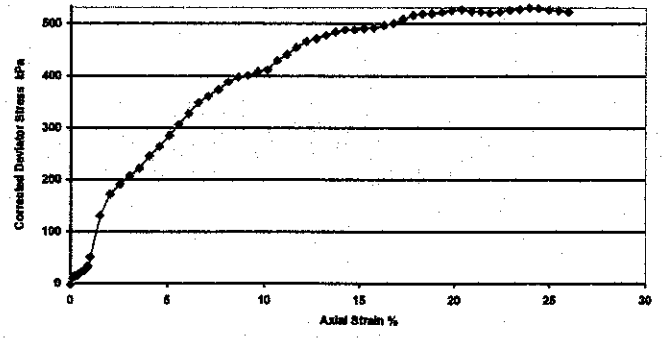
Client	3UD	Lab Ref	
Project		Job	3UD
Borehole		Sample	3UD

Test Details			
Standard	BS 1377 : Part 7 : Clause 8	Particle Density	2.65 Mg/m3
Sample Type		Lab. Temperature	0.0 deg.C
Sample Description			
Variations from Procedure			

Specimen Details			
Specimen Reference	C1	Stage Reference	1
Depth within Sample	0.00mm	Description	
Initial Height	76.00 mm	Orientation within Sample	
Preparation		Initial Diameter	38.00 mm
Initial Bulk Density	0.00 Mg/m3	Initial Moisture Content*	-100.0 %
Initial Dry Density	2.26 Mg/m3	Membrane Thickness	0.20 mm
Comments			

* Calculated from initial and dry weights of whole specimen

Shearing Stage (Stress Vs Axial Strain %)



Generated by Foxit PDF Creator © Foxit Software
http://www.foxitsoftware.com For evaluation only.

Undrained Shear Strength in Triaxial Compression without measurement of Pore Pressure (Quick Undrained)

ELE International

Client	3UD	Lab Ref	
Project		Job	3UD
Borehole		Sample	3UD

Shear Conditions			
Rate of Axial Strain	2.03%/min	Cell Pressure	401.2kPa

Conditions at Failure			
Failure Criterion	Maximum Deviator Stress or Maximum allowed Strain		
Maximum Corrected Deviator Stress	534kPa	Shear Strength	267kPa
Axial Strain	23.95%		
Deviator Stress Correction	2.0 kPa		
Final Density	2.32 Mg/m3	Final Moisture Content	2.6 %

Mode of Failure

Tested By and Date:	
Checked By and Date:	
Approved By and Date:	

Undrained Shear Strength in Triaxial Compression without measurement of Pore Pressure (Quick Undrained)

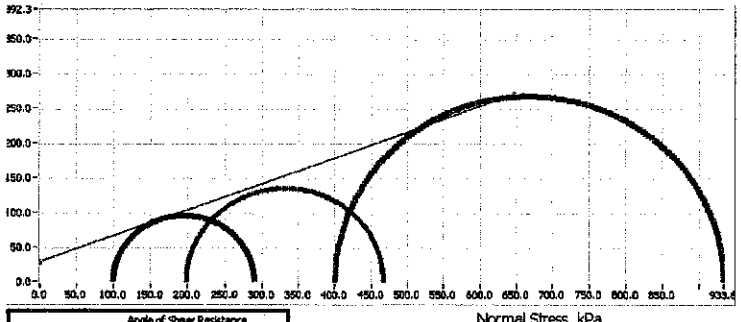
ELE International

SUMMARY

All Stages Conditions at Failure					
Ref	Cell Pressure	Max. Corrected Deviator Stress	Cumulative Strain	Mode of Failure	Shear Strength
Stage1	99.8kPa	190kPa	16.32%	Maximum Deviator Stress or Maximum allowed Strain	95kPa
Stage3	198.0kPa	268kPa	12.67%	Maximum Deviator Stress or Maximum allowed Strain	134kPa
Stage2	399.9kPa	534kPa	23.95%	Maximum Deviator Stress or Maximum allowed Strain	267kPa

Shear Stress kPa

Mohr Circles



Normal Stress kPa

Shear Strength Properties

Angle of Shear Resistance: 20.45 Degrees

Cohesion: 28.96 kPa

Undrained Shear Strength in Triaxial Compression without measurement of Pore Pressure (Quick Undrained)

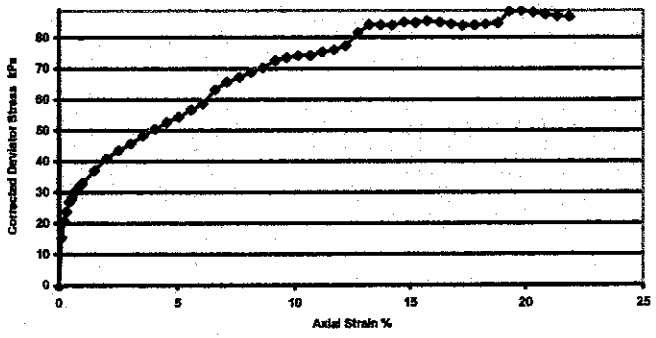
ELE International

Client	4R	Ref	
Project		Job	4R
Borehole		Sample	4R

Test Details			
Standard	BS 1377 : Part 7 : Clause 8	Particle Density	2.65 Mg/m3
Sample Type	Core sample		
Lab. Temperature	0.0 deg.C	Variations from procedure	

Specimen Details			
Specimen Reference	A1	Stage Reference	1
Depth within Sample	0.00mm	Description	
Initial Height	76.00 mm	Orientation within Sample	
Preparation		Initial Diameter	38.00 mm
Initial Bulk Density	0.00 Mg/m3	Initial Moisture Content	0.00 %
Initial Dry Density	2.26 Mg/m3	Membrane Thickness	0.20 mm
Comments			

Shearing Stage (Stress Vs Axial Strain %)



Generated by Foxit PDF Creator © Foxit Software
http://www.foxitsoftware.com For evaluation only.

Undrained Shear Strength in Triaxial Compression without measurement of Pore Pressure (Quick Undrained)

ELE International

Client	4R	Ref	
Project		Job	4R
Borehole		Sample	4R

Shear Conditions			
Rate of Axial Strain	2.03%/min	Cell Pressure	99.6kPa

Conditions at Failure			
Failure Criterion	Maximum Deviator Stress or Maximum allowed Strain		
Maximum Corrected Deviator Stress	89kPa	Shear Strength	44kPa
Axial Strain	19.31%		
Deviator Stress Correction	1.9 kPa		
Final Density	2.32 Mg/m3	Final Moisture Content	2.56 %

Mode of Failure

Tested By and Date:	
Checked By and Date:	
Approved By and Date:	

Client	4R	Ref	
Project		Job	4R

Undrained Shear Strength in Triaxial Compression without measurement of Pore Pressure (Quick Undrained)

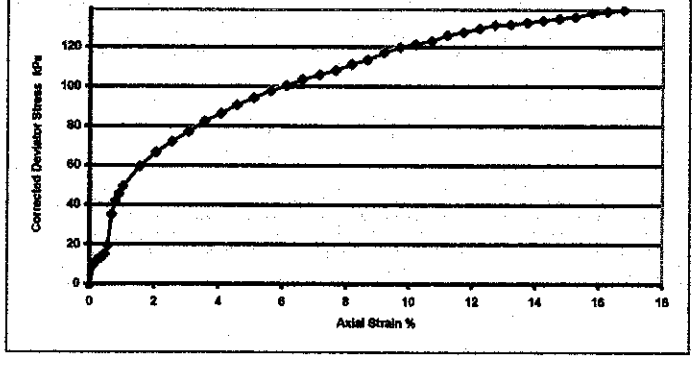
ELE International

Borehole		Sample	4R

Test Details			
Standard	BS 1377 : Part 7 : Clause 8	Particle Density	2.65 Mg/m3
Sample Type	Core sample		
Lab. Temperature	0.0 deg.C	Variations from procedure	

Specimen Details			
Specimen Reference	C1	Stage Reference	1
Depth within Sample	0.00mm	Description	
Initial Height	76.00 mm	Orientation within Sample	
Preparation		Initial Diameter	38.00 mm
Initial Bulk Density	0.00 Mg/m3	Initial Moisture Content	-100.0 %
Initial Dry Density	2.32 Mg/m3	Membrane Thickness	0.20 mm
Comments			

Shearing Stage (Stress Vs Axial Strain %)



Generated by Foxit PDF Creator © Foxit Software
http://www.foxitsoftware.com For evaluation only.

Undrained Shear Strength in Triaxial Compression without measurement of Pore Pressure (Quick Undrained)

ELE International

Client	4R	Ref	
Project		Job	4R
Borehole		Sample	4R

Shear Conditions			
Rate of Axial Strain	2.03%/min	Cell Pressure	312.9kPa

Conditions at Failure			
Failure Criterion	Maximum Deviator Stress or Maximum allowed Strain		
Maximum Corrected Deviator Stress	140kPa	Shear Strength	70kPa
Axial Strain	16.77%		
Deviator Stress Correction	1.7 kPa		
Final Density	2.32 Mg/m3	Final Moisture Content	0.0 %

Mode of Failure

Tested By and Date:	
Checked By and Date:	
Approved By and Date:	

SUMMARY

Undrained Shear Strength in Triaxial Compression without measurement of Pore Pressure (Quick Undrained)

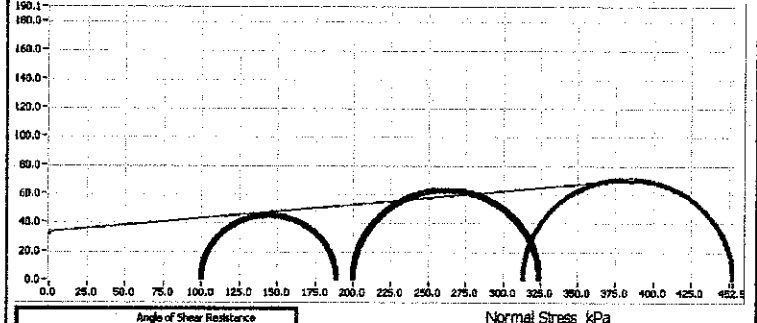
ELE International

All Stages
Conditions at Failure

Ref	Cell Pressure	Max. Corrected Deviator Stress	Cumulative Strain	Mode of Failure	Shear Strength
Stage1	99.6kPa	89kPa	19.31%	Maximum Deviator Stress or Maximum allowed Strain	44kPa
Stage2	199.6kPa	124kPa	13.21%	Maximum Deviator Stress or Maximum allowed Strain	62kPa
Stage3	312.9kPa	140kPa	16.77%	Maximum Deviator Stress or Maximum allowed Strain	70kPa

Shear Stress kPa

Mohr Circles



Normal Stress kPa

Shear Strength Properties

Angle of Shear Resistance: 5.39 Degrees

Cohesion: 33.18 kPa

Undrained Shear Strength in Triaxial Compression without measurement of Pore Pressure (Quick Undrained)

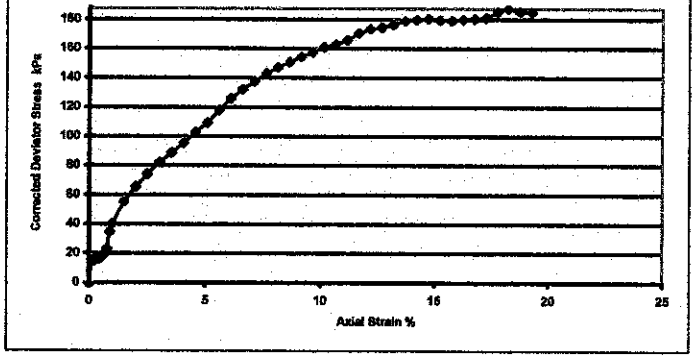
ELE International

Client	4UD	Ref	
Project		Job	4UD
Borehole		Sample	4UD

Test Details			
Standard	BS 1377 : Part 7 : Clause 8	Particle Density	2.65 Mg/m3
Sample Type	Core sample		
Lab. Temperature	0.0 deg.C	Variations from procedure	

Specimen Details			
Specimen Reference	A1	Stage Reference	1
Depth within Sample	0.00mm	Description	
Initial Height	76.00 mm	Orientation within Sample	
Preparation		Initial Diameter	38.00 mm
Initial Bulk Density	0.00 Mg/m3	Initial Moisture Content	-100.0 %
Initial Dry Density	2.26 Mg/m3	Membrane Thickness	0.20 mm
Comments			

Shearing Stage (Stress Vs Axial Strain %)



Generated by Foxit PDF Creator © Foxit Software
http://www.foxitsoftware.com For evaluation only.

Undrained Shear Strength in Triaxial Compression without measurement of Pore Pressure (Quick Undrained)

ELE International

Client	4UD	Ref	
Project		Job	4UD
Borehole		Sample	4UD

Shear Conditions			
Rate of Axial Strain	2.03%/min	Cell Pressure	99.0kPa

Conditions at Failure			
Failure Criterion	Maximum Deviator Stress or Maximum allowed Strain		
Maximum Corrected Deviator Stress	188kPa	Shear Strength	94kPa
Axial Strain	18.26%		
Deviator Stress Correction	1.9 kPa		
Final Density	2.32 Mg/m3	Final Moisture Content	2.6 %

Tested By and Date:	
Checked By and Date:	
Approved By and Date:	

Mode of Failure

Client	4UD	Ref	
Project		Job	4UD

Undrained Shear Strength In Triaxial Compression without measurement of Pore Pressure (Quick Undrained)

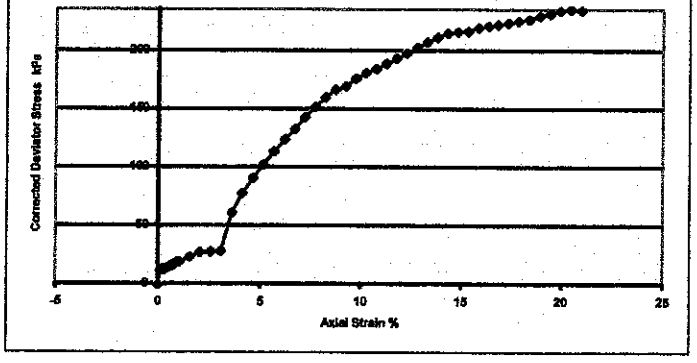
ELE International

Borehole		Sample	4UD

Test Details			
Standard	BS 1377 : Part 7 : Clause 8	Particle Density	2.65 Mg/m3
Sample Type	Core sample		
Lab. Temperature	0.0 deg.C	Variations from procedure	

Specimen Details			
Specimen Reference	B1	Stage Reference	1
Depth within Sample	0.00mm	Description	
Initial Height	76.00 mm	Orientation within Sample	
Preparation		Initial Diameter	38.00 mm
Initial Bulk Density	0.00 Mg/m3	Initial Moisture Content	-100.0 %
Initial Dry Density	2.32 Mg/m3	Membrane Thickness	0.20 mm
Comments			

Shearing Stage (Stress Vs Axial Strain %)



Undrained Shear Strength In Triaxial Compression without measurement of Pore Pressure (Quick Undrained)

ELE International

Client	4UD	Ref	
Project		Job	4UD
Borehole		Sample	4UD

Shear Conditions			
Rate of Axial Strain	2.03%/min	Cell Pressure	198.9kPa

Conditions at Failure			
Failure Criterion	Maximum Deviator Stress or Maximum allowed Strain		
Maximum Corrected Deviator Stress	236kPa	Shear Strength	118kPa
Axial Strain	20.42%		
Deviator Stress Correction	2.0 kPa		
Final Density	2.32 Mg/m3	Final Moisture Content	0.0 %

Mode of Failure

Tested By and Date:	
Checked By and Date:	
Approved By and Date:	

Client	4UD	Ref	
Project		Job	4UD

Undrained Shear Strength in Triaxial Compression without measurement of Pore Pressure (Quick Undrained)

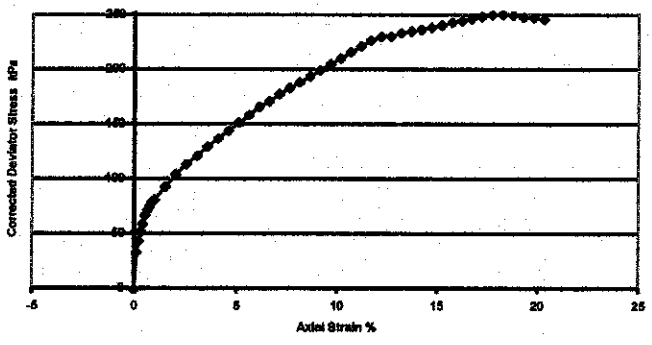
ELE International

Borehole		Sample	4UD

Test Details			
Standard	BS 1377 : Part 7 : Clause 8	Particle Density	2.65 Mg/m3
Sample Type	Core sample		
Lab. Temperature	0.0 deg.C	Variations from procedure	

Specimen Details			
Specimen Reference	C1	Stage Reference	1
Depth within Sample	0.00mm	Description	
Initial Height	76.00 mm	Orientation within Sample	
Preparation		Initial Diameter	38.00 mm
Initial Bulk Density	0.00 Mg/m3	Initial Moisture Content	0.00 %
Initial Dry Density	2.15 Mg/m3	Membrane Thickness	0.20 mm
Comments			

Shearing Stage (Stress Vs Axial Strain %)



Undrained Shear Strength in Triaxial Compression without measurement of Pore Pressure (Quick Undrained)

ELE International

Client	4UD	Ref	
Project		Job	4UD
Borehole		Sample	4UD

Shear Conditions			
Rate of Axial Strain	2.03%/min	Cell Pressure	352.0kPa

Conditions at Failure			
Failure Criterion	Maximum Deviator Stress or Maximum allowed Strain		
Maximum Corrected Deviator Stress	251kPa	Shear Strength	126kPa
Axial Strain	18.27%		
Deviator Stress Correction	1.9 kPa		
Final Density	2.20 Mg/m3	Final Moisture Content	2.70 %

Mode of Failure

Tested By and Date:	
Checked By and Date:	
Approved By and Date:	

SUMMARY

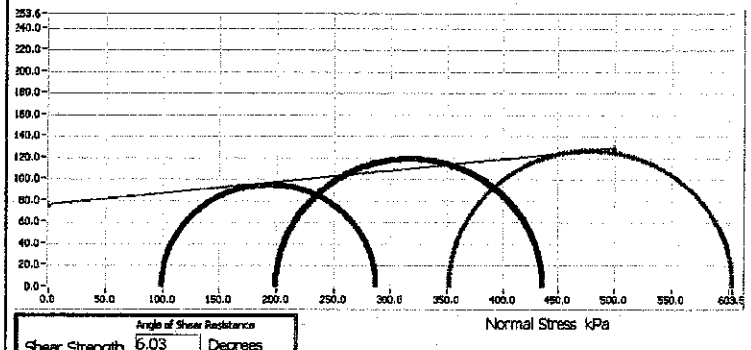
Undrained Shear Strength in Triaxial Compression without measurement of Pore Pressure (Quick Undrained)

ELE International

All Stages
Conditions at Failure

Ref	Cell Pressure	Max. Corrected Deviator Stress	Cumulative Strain	Mode of Failure	Shear Strength
Stage1	99.0kPa	188kPa	18.26%	Maximum Deviator Stress or Maximum allowed Strain	94kPa
Stage2	198.9kPa	236kPa	20.42%	Maximum Deviator Stress or Maximum allowed Strain	118kPa
Stage3	352.0kPa	251kPa	18.27%	Maximum Deviator Stress or Maximum allowed Strain	126kPa

Mohr Circles



Shear Strength Properties

Angle of Shear Resistance: 6.03 Degrees

Cohesion: 75.73 kPa

Undrained Shear Strength in Triaxial Compression without measurement of Pore Pressure (Quick Undrained)

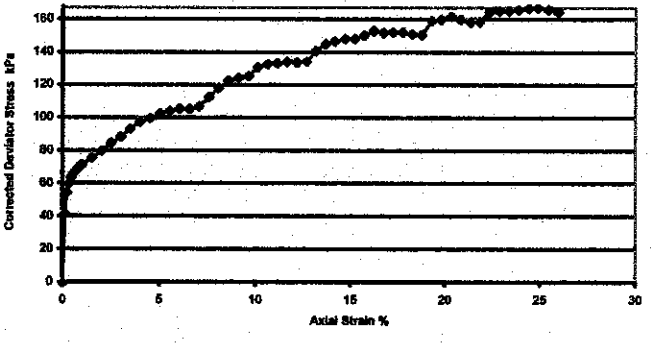
ELE International

Client	5R	Ref	
Project		Job	5R
Borehole		Sample	5R

Test Details			
Standard	BS 1377 : Part 7 : Clause 8	Particle Density	2.65 Mg/m3
Sample Type			
Lab. Temperature	0.0 deg.C	Variations from procedure	

Specimen Details			
Specimen Reference	A1	Stage Reference	1
Depth within Sample	0.00mm	Description	
Initial Height	76.00 mm	Orientation within Sample	
Preparation		Initial Diameter	38.00 mm
Initial Bulk Density	0.00 Mg/m3	Initial Moisture Content	0.00 %
Initial Dry Density	2.26 Mg/m3	Membrane Thickness	0.20 mm
Comments			

Shearing Stage (Stress Vs Axial Strain %)



Generated by Foxit PDF Creator © Foxit Software
http://www.foxitsoftware.com For evaluation only.

Undrained Shear Strength in Triaxial Compression without measurement of Pore Pressure (Quick Undrained)

ELE International

Client	5R	Ref	
Project		Job	5R
Borehole		Sample	5R

Shear Conditions			
Rate of Axial Strain	2.03%/min	Cell Pressure	99.8kPa

Conditions at Failure			
Failure Criterion	Maximum Deviator Stress or Maximum allowed Strain		
Maximum Corrected Deviator Stress	154kPa	Shear Strength	77kPa
Axial Strain	16.24%		
Deviator Stress Correction	1.7 kPa		
Final Density	2.32 Mg/m3	Final Moisture Content	2.56 %

Mode of Failure

Tested By and Date:	
Checked By and Date:	
Approved By and Date:	

Client	5R	Ref	
Project		Job	5R

Undrained Shear Strength in Triaxial Compression without measurement of Pore Pressure (Quick Undrained)

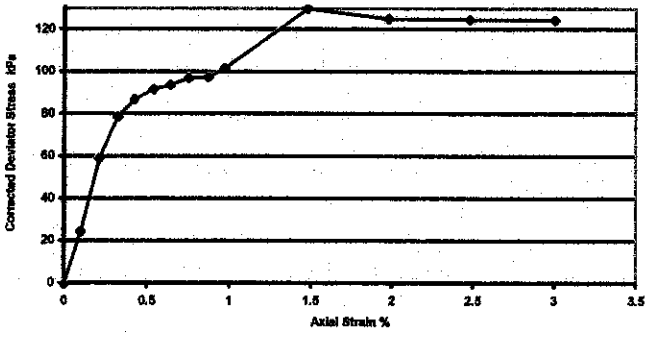
ELE International

Borehole		Sample	5R

Test Details			
Standard	BS 1377 : Part 7 : Clause 8	Particle Density	2.65 Mg/m3
Sample Type			
Lab. Temperature	0.0 deg.C	Variations from procedure	

Specimen Details			
Specimen Reference	B1	Stage Reference	1
Depth within Sample	0.00mm	Description	
Initial Height	76.00 mm	Orientation within Sample	
Preparation		Initial Diameter	38.00 mm
Initial Bulk Density	0.00 Mg/m3	Initial Moisture Content	0.00 %
Initial Dry Density	2.26 Mg/m3	Membrane Thickness	0.20 mm
Comments			

Shearing Stage (Stress Vs Axial Strain %)



Generated by Foxit PDF Creator © Foxit Software
http://www.foxitsoftware.com For evaluation only.

Undrained Shear Strength in Triaxial Compression without measurement of Pore Pressure (Quick Undrained)

ELE International

Client	5R	Ref	
Project		Job	5R
Borehole		Sample	5R

Shear Conditions			
Rate of Axial Strain	2.03%/min	Cell Pressure	199.6kPa

Conditions at Failure			
Failure Criterion	Maximum Deviator Stress or Maximum allowed Strain		
Maximum Corrected Deviator Stress	130kPa	Shear Strength	65kPa
Axial Strain	1.48%		
Deviator Stress Correction	0.2 kPa		
Final Density	2.32 Mg/m3	Final Moisture Content	2.56 %

Tested By and Date:	
Checked By and Date:	
Approved By and Date:	

Mode of Failure

Undrained Shear Strength in Triaxial Compression without measurement of Pore Pressure (Quick Undrained)

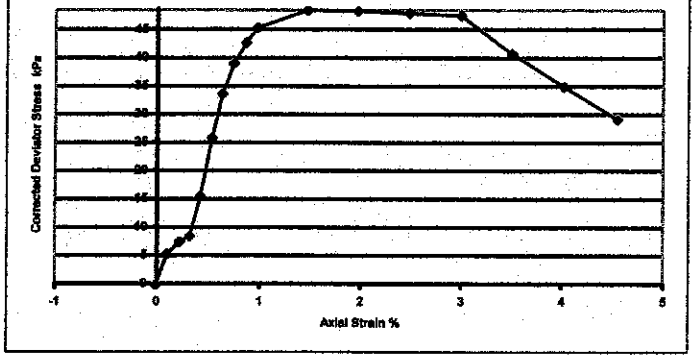
ELE International

Client	5R	Ref	
Project		Job	5R
Borehole		Sample	5R

Test Details			
Standard	BS 1377 : Part 7 : Clause 8	Particle Density	2.65 Mg/m3
Sample Type			
Lab. Temperature	0.0 deg.C	Variations from procedure	

Specimen Details			
Specimen Reference	C1	Stage Reference	1
Depth within Sample	0.00mm	Description	
Initial Height	76.00 mm	Orientation within Sample	
Preparation		Initial Diameter	38.00 mm
Initial Bulk Density	0.00 Mg/m3	Initial Moisture Content	0.00 %
Initial Dry Density	2.26 Mg/m3	Membrane Thickness	0.20 mm
Comments			

Shearing Stage (Stress Vs Axial Strain %)



Generated by Foxit PDF Creator © Foxit Software
http://www.foxitsoftware.com For evaluation only.

Undrained Shear Strength in Triaxial Compression without measurement of Pore Pressure (Quick Undrained)

ELE International

Client	5R	Ref	
Project		Job	5R
Borehole		Sample	5R

Shear Conditions			
Rate of Axial Strain	2.03%/min	Cell Pressure	400.8kPa

Conditions at Failure			
Failure Criterion	Maximum Deviator Stress or Maximum allowed Strain		
Maximum Corrected Deviator Stress	49kPa	Shear Strength	24kPa
Axial Strain	1.47%		
Deviator Stress Correction	0.2 kPa		
Final Density	2.32 Mg/m3	Final Moisture Content	2.56 %

Mode of Failure

Tested By and Date:	
Checked By and Date:	
Approved By and Date:	

SUMMARY

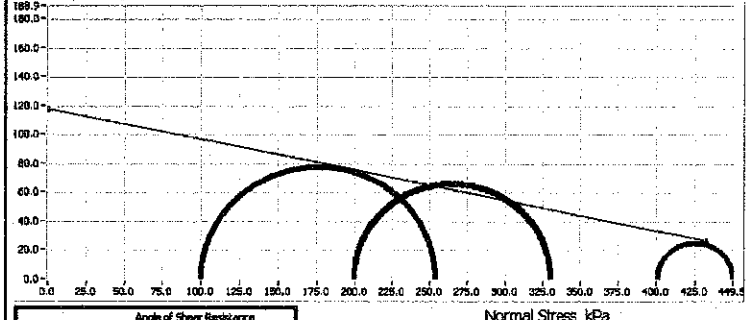
Undrained Shear Strength In Triaxial Compression without measurement of Pore Pressure (Quick Undrained)

ELE International

All Stages
Conditions at Failure

Ref	Cell Pressure	Max. Corrected Deviator Stress	Cumulative Strain	Mode of Failure	Shear Strength
Stage1	99.8kPa	154kPa	16.24%	Maximum Deviator Stress or Maximum allowed Strain	77kPa
Stage2	199.6kPa	130kPa	1.48%	Maximum Deviator Stress or Maximum allowed Strain	65kPa
Stage3	400.6kPa	49kPa	1.47%	Maximum Deviator Stress or Maximum allowed Strain	24kPa

Mohr Circles



Shear Strength Properties
Angle of Shear Resistance 11.92 Degrees
Cohesion 117.25 kPa

Undrained Shear Strength in Triaxial Compression without measurement of Pore Pressure (Quick Undrained)

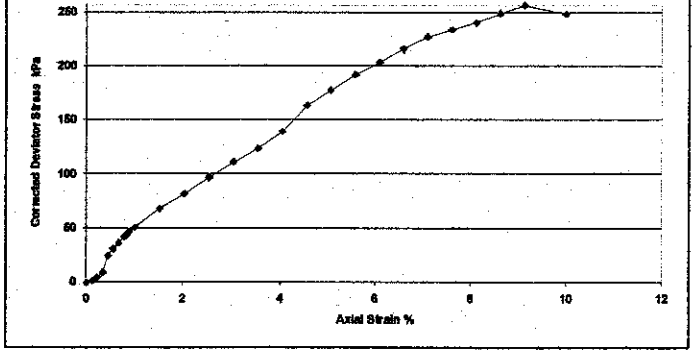
ELE International

Client	5UD	Ref	
Project		Job	5UD
Borehole		Sample	5UD

Test Details			
Standard	BS 1377 : Part 7 : Clause 8	Particle Density	2.65 Mg/m3
Sample Type			
Lab. Temperature	0.0 deg.C	Variations from procedure	

Specimen Details			
Specimen Reference	A1	Stage Reference	1
Depth within Sample	0.00mm	Description	
Initial Height	76.00 mm	Orientation within Sample	
Preparation		Initial Diameter	38.00 mm
Initial Bulk Density	0.00 Mg/m3	Initial Moisture Content	0.00 %
Initial Dry Density	2.30 Mg/m3	Membrane Thickness	0.20 mm
Comments			

Shearing Stage (Stress Vs Axial Strain %)



Generated by Foxit PDF Creator © Foxit Software
http://www.foxitsoftware.com For evaluation only.

Undrained Shear Strength in Triaxial Compression without measurement of Pore Pressure (Quick Undrained)

ELE International

Client	5UD	Ref	
Project		Job	5UD
Borehole		Sample	5UD

Shear Conditions			
Rate of Axial Strain	2.03%/min	Cell Pressure	101.8kPa

Conditions at Failure			
Failure Criterion	Maximum Deviator Stress or Maximum allowed Strain		
Maximum Corrected Deviator Stress	258kPa	Shear Strength	129kPa
Axial Strain	9.14%		
Deviator Stress Correction	1.2 kPa		
Final Density	2.32 Mg/m3	Final Moisture Content	1.01 %

Mode of Failure

Tested By and Date:	
Checked By and Date:	
Approved By and Date:	

Undrained Shear Strength in Triaxial Compression without measurement of Pore Pressure (Quick Undrained)

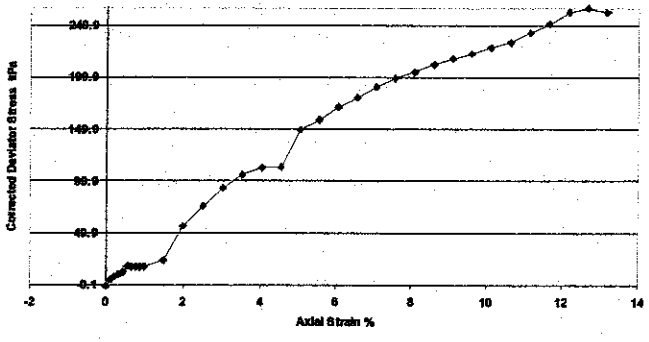
ELE International

Client	5UD	Ref	
Project		Job	5UD
Borehole		Sample	5UD

Test Details			
Standard	BS 1377 : Part 7 : Clause 8	Particle Density	2.65 Mg/m3
Sample Type			
Lab. Temperature	0.0 deg.C	Variations from procedure	

Specimen Details			
Specimen Reference	B1	Stage Reference	1
Depth within Sample	0.00mm	Description	
Initial Height	76.00 mm	Orientation within Sample	
Preparation		Initial Diameter	38.00 mm
Initial Bulk Density	0.00 Mg/m3	Initial Moisture Content	0.00 %
Initial Dry Density	2.27 Mg/m3	Membrane Thickness	0.20 mm
Comments			

Shearing Stage (Stress Vs Axial Strain %)



Generated by Foxit PDF Creator © Foxit Software
http://www.foxitsoftware.com For evaluation only.

Undrained Shear Strength in Triaxial Compression without measurement of Pore Pressure (Quick Undrained)

ELE International

Client	5UD	Ref	
Project		Job	5UD
Borehole		Sample	5UD

Shear Conditions			
Rate of Axial Strain	2.03%/min	Cell Pressure	198.0kPa

Conditions at Failure			
Failure Criterion	Maximum Deviator Stress or Maximum allowed Strain		
Maximum Corrected Deviator Stress	268kPa	Shear Strength	134kPa
Axial Strain	12.67%		
Deviator Stress Correction	1.5 kPa		
Final Density	2.32 Mg/m3	Final Moisture Content	2.04 %

Mode of Failure

Tested By and Date:	
Checked By and Date:	
Approved By and Date:	

Undrained Shear Strength in Triaxial Compression without measurement of Pore Pressure (Quick Undrained)

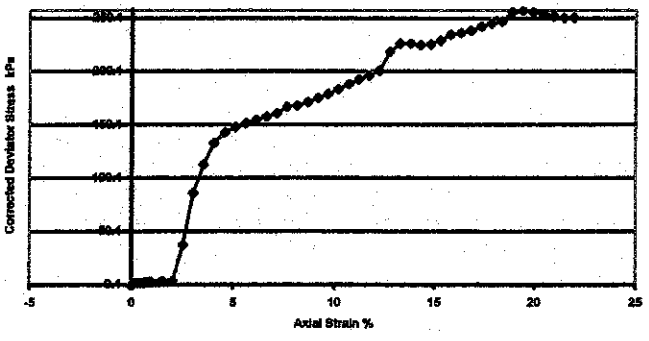
ELE International

Client	5UD	Ref	
Project		Job	5UD
Borehole		Sample	5UD

Test Details			
Standard	BS 1377 : Part 7 : Clause 8	Particle Density	2.65 Mg/m3
Sample Type			
Lab. Temperature	0.0 deg.C	Variations from procedure	

Specimen Details			
Specimen Reference	C1	Stage Reference	1
Depth within Sample	0.00mm	Description	
Initial Height	76.00 mm	Orientation within Sample	
Preparation		Initial Diameter	38.00 mm
Initial Bulk Density	0.00 Mg/m3	Initial Moisture Content	0.00 %
Initial Dry Density	2.27 Mg/m3	Membrane Thickness	0.20 mm
Comments			

Shearing Stage (Stress Vs Axial Strain %)



Generated by Foxit PDF Creator © Foxit Software
http://www.foxitsoftware.com For evaluation only.

Undrained Shear Strength in Triaxial Compression without measurement of Pore Pressure (Quick Undrained)

ELE International

Client	5UD	Ref	
Project		Job	5UD
Borehole		Sample	5UD

Shear Conditions			
Rate of Axial Strain	2.03%/min	Cell Pressure	399.9kPa

Conditions at Failure			
Failure Criterion	Maximum Deviator Stress or Maximum allowed Strain		
Maximum Corrected Deviator Stress	258kPa	Shear Strength	129kPa
Axial Strain	19.41%		
Deviator Stress Correction	2.0 kPa		
Final Density	237.84 Mg/m3	Final Moisture Content	10359.18 %

Mode of Failure

Tested By and Date:	
Checked By and Date:	
Approved By and Date:	

SUMMARY

Undrained Shear Strength in Triaxial Compression without measurement of Pore Pressure (Quick Undrained)

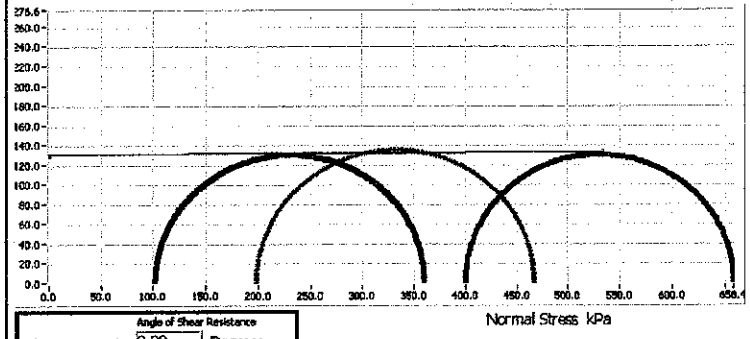
ELE International

All Stages

Conditions at Failure

Ref	Cell Pressure	Max. Corrected Deviator Stress	Cumulative Strain	Mode of Failure	Shear Strength
Stage1	101.6kPa	258kPa	9.14%	Maximum Deviator Stress or Maximum allowed Strain	129kPa
Stage2	198.0kPa	268kPa	12.67%	Maximum Deviator Stress or Maximum allowed Strain	134kPa
Stage3	399.9kPa	258kPa	19.41%	Maximum Deviator Stress or Maximum allowed Strain	129kPa

Mohr Circles



Shear Strength Properties

Angle of Shear Resistance: 0.20 Degrees

Cohesion: 129.97 kPa